NCHRP Web Document 38 (Project D10-54): Contractor's Final Report

Quality-Based Performance Rating of Contractors for Prequalification and Bidding Purposes

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Submitted by:

R. E. Minchin Jr.
G. R. Smith
Pennsylvania State University
University Park, Pennsylvania

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CHAPTER ONE

INTRODUCTION

BACKGROUND

It has long been a source of frustration to those involved with competitive-bid construction projects that owners often treat low-quality construction work no differently than high-quality construction work. Both owners and contractors have acknowledged this problem. From the very first Focus Group meeting that this research team held, and with few exceptions thereafter, contractors who were confident in their ability to produce high-quality work expressed their perceptions that public owners actually reward poor workmanship, at least indirectly.

According to the contractors, they do this by not penalizing poor workmanship, thus giving a bidding edge to those contractors who are not above taking advantage of the owners' reluctance to penalize them. These contractors are discouraged about the prospect of continuing to bid for construction work against contractors who consistently submit low bids and produce low-quality products. In many cases, it was expressed that these same low-bidding contractors consistently submit claims for extras—even when the claimed work was part of the original design. No evidence was provided, however, to support these claims.

Department of Transportation (DOT) officials have expressed this same concern. In private meetings, some state highway agency officials expressed concern regarding implementation of quality-based prequalification. In many cases, the prequalification personnel have been instructed by their superiors to consider the quality of a contractor's past work as part of the process of prequalification or qualification of contractors but have been given no set procedure for doing so.

The state highway agencies that comprise the American Association of State Highway and Transportation Officials (AASHTO) obviously shared these concerns and requested that the National Cooperative Highway Research Program (NCHRP) fund research to develop a Quality-Based Performance Rating (QBPR) system.

Although earlier studies on contractor prequalification have summarized the state-of-the-art, the systems reviewed rely primarily on analysis of financial indicators to determine contractor performance capability—mostly to the exclusion of all else. These earlier studies indicate that, in a vast majority of states, a contractor's performance must be substantially and consistently below tolerances before action is taken to lower or eliminate the contractor's qualification status. The need to develop an evaluation tool for contractor performance using traditional and non-traditional quality performance criteria is evident.

OBJECTIVES AND SCOPE

The purpose of this study was to develop a comprehensive quality-based rating system that will be effective in prequalification systems and bid evaluation. To avoid any misunderstanding, the discussion will often focus on prequalification procedures because, in most instances, the factors important to quality can be measured in a fashion similar to current prequalification procedures. Post-qualification and other techniques to ensure contractor responsibility are certainly not excluded from consideration.

The result of this study is a rating system to help determine qualification for construction contract awards. The same system also could be used to determine bidder responsibility in those states not conducting prequalification procedures, provided they collect and retain similar data. An additional possibility is for quality to become a part of the actual bidding process, with this system generating the quality factor. To DOTs, the result is a much-needed procedure for considering the quality of past work to determine contractor eligibility for contract awards and for using quality as a factor in determining contractor disqualification.

Any system and procedure to be used for this purpose must meet certain criteria. A list of these criteria would include, but would not necessarily be limited to:

> **Ease-of-use.** The eventual hands-on user of this system will be DOT or consultant personnel at the technician level. A complicated system would have limited use.
>
> **Flexibility.** Each state has its own laws, rules, regulations, and procedures. It is neither the task of this research team to formulate a system that is acceptable under all state regulations, nor will the system be ready for immediate use by every potential user. There are simply too many differences in the way different states handle contractor qualification, performance rating, and awarding of contracts. A method that can be customized to each user is needed and, ideally, would also retain quality performance data for export to other agencies.
>
> **Fairness.** The system should be as objective as possible; it can be neither arbitrary nor capricious. The greatest fear expressed by contractors at the Focus Group meetings was the fear of being injured by subjective ratings. This was the research team's toughest challenge.

In short, particular emphasis had to be placed on ensuring that the system was comprehensive enough to identify possible qualification problems in bidding contractors, yet simple enough so that DOTs are willing to implement the system.

RESEARCH APPROACH

Task 1: Review the state of the practice on quality-based performance rating systems

The purpose of this task was to scour the existing literature for relevant publications that would provide a benchmark or base examination of the procedures used to evaluate overall contractor performance. Both domestic and international sources were included in the search domain.

Task 2: Identify Factors to be Used in the QBPR System

Objective and subjective factors were to be considered as part of the system. It was acknowledged at the onset of this project that objective measurements would most likely realize wider acceptance. Justification of all factors would be sought through concurrence of industry. Implementation could not be ignored in the preparation of the model.

Task 3: Propose a Conceptual QBPR System

Factors to be included in the examination of quality were to be formulated into a model. Models take various forms and several were considered. Factors to be included in the model were identified and evaluated by both the contracting community and the state DOTs. This provided a categorical listing of the factors and suggested measurement criteria.

After the literature search identified a wide variety of factors, the team set up Focus Group meetings in four states. Three of these Focus Groups contained roughly equal numbers of contractor and DOT personnel. The meetings were held in Utah, Florida, and Pennsylvania; in addition, a meeting was held in Kentucky with DOT personnel only. The meeting agendas were identical to ensure consistency in discussion but were not limiting in terms of topics discussed.

Using the data generated by the Focus Groups, the team produced a survey, which was then distributed to every DOT Construction Section in the United States, including the District of Columbia and Puerto Rico. In addition, 400 contractors who are members of the Associated Pennsylvania Constructors and the Florida Transportation Builders Association were given copies of the survey. Supplemental to the broader distribution, a limited number of contractors in Kentucky and Utah also received and returned the survey. The key outcome of the survey was a rank-order list of factors related to the quality of a construction project.

Task 4: Interim Report

An interim report was prepared documenting the work completed for the first three tasks and modifying the work to be accomplished in the remaining tasks.

Task 5: Develop the Approved QBPR System and Draft a Procedure Manual

The development of the QBPR system included suggested measures for each of the factors that related to quality. A weighted matrix scheme allowed for flexibility in assigning the criteria. Proper balance among the data collected by a project questionnaire and data generated from materials test reports were important. These QBPR factors will also be considered for use as a "C" factor in multiple criteria bidding and the awarding of contracts in the "A+B+C" or "A+C" bidding scenario. The procedure manual originally proposed in the research was abandoned due to the overwhelming variation of existing DOT qualification processes.

Task 6: Validate the QBPR System

Once the system was ready, it was field-tested using project records from four states. Each state was asked to provide internal reports or data on at least one recent project for high quality projects, low-quality projects, and average-quality projects. Qualifications in three work classifications were used; pavement construction was divided into asphalt pavement and concrete pavement construction, structural construction was the final category. Also, several projects had both bridge and paving components and were handled separately. For additional analysis, one contractor was tracked in Pennsylvania. This contractor's projects were graded over a five-year period through five districts within the state, thus giving the model the opportunity to develop a contractor factor (CF) for this contractor, the actual index which is the indicator of a contractor's quality rating.

The records and DOT personnel assigned to these projects provided the data used in the system. While it was hoped that the system would consistently rate projects at the quality level which the projects attained under the state's current system or at a level agreed upon by department personnel, some discrepancies were apparent between the perceived valuation of the work at one level and the scored performance at other levels of organizations. These issues will be discussed in more detail.

Task 7: Prepare an Implementation Plan for Transportation Agencies

The concept of the stand-alone procedural manual for implementation was deleted from the scope of the deliverables for this project. However, the need for implementation to take into account different contractor sizes, project scopes, and managing new firms and joint ventures and other factors did not change and an implementation plan has been produced as an element of Task 7. Specific legal issues regarding the appeal process, duration of disqualification, and other concerns were addressed on the basis of existing precedent cases (where they could be identified). A person with an appropriate legal background was asked to validate the system's legality in order to eliminate arbitrary or capricious conditions.

Task 8: Prepare the Final Report

A final report documenting the entire research process and development of the QBPR system will be submitted. The report will contain an executive summary and highlight the critical elements of the QBPR system.

ORGANIZATION OF THIS REPORT

Chapter One is a basic introduction and discussion of the tasks of the project. Chapter Two summarizes the Literature Review. Chapter Three discusses the factors identified as candidates for the model and the rationale behind the factors selected. Chapter Four presents discussion of model formulations and the formulation based on the information obtained from focus group sessions and other sources. Chapter Five describes the data collection, analysis, and model validation for the project. Chapter Six is a discussion of implementation issues for the proposed quality based system. Chapter Seven presents the research conclusions and related observations along with recommendations for future work on the model.

CHAPTER TWO

LITERATURE REVIEW

INTRODUCTION

Public owners are constantly striving to develop mechanisms that will allow only qualified contractors to competitively bid on their projects. Quality-based qualification is another step in the evolution of quality assurance in public construction. In reality, this is a rather bold move in an industry that has barely moved forward from 1930's 'final product point inspection' procedures. Traditionally, relatively few contractors have fully implemented total quality control, quality management, or quality assurance procedures to address all facets of quality. Changes in regulations regarding use of contractor quality testing in quality assurance decisions and continuing reduction in DOT personnel will increase the need for 'quality driven' contractors in public transportation construction projects. This change, coupled with more departments adopting performance-based and performance-related specifications, places more need on contractors to know and use quality management in their field operations management. With more contractors providing the quality control function, the DOTs' role would change to a quality assurance role. As one part of the quality assurance process, there is a need for comprehensive methods to evaluate a contractor's eligibility to engage in work from a quality perspective; thus, there is a need for examining quality performance measurement techniques and approaches.

A detailed literature search was conducted using The Pennsylvania State University Library (including access to all Big Ten university libraries), the Inter-Library Loan Program, and the Transportation Research Information Services (TRIS). The scope of the collections covered by this search included domestic and foreign periodicals, journals, books, conference proceedings, and standard references. Many volumes were received from external libraries through the Inter-Library Loan Program. In addition to the literature from archive library reserves, the DOTs were solicited to provide information on their qualifications requirements for quality performance. Materials collected were analyzed, summarized, and made part of the knowledge used to research this topic.

QUALIFICATION PROCESSES

Although the term "quality" is mentioned frequently as an attribute for contractor qualification systems, there was no evidence of data or models found that established or proposed relationships between quality and contractor qualification. The ideology of quality in qualification of contractors is given significant coverage, but at the time the literature search was conducted, no one had definitely created a link between the two concepts.

Thomas and Smith (1994) identified four strategies that DOTs use to qualify contractors:

- Prequalification.

- Post-qualification.
- Performance Bonds.
- Contractor Licensing.

Prequalification, in very simple terms, is a review of information submitted by the contractor, allowing the qualifying agency to determine the contractor's eligibility to bid certain types of work. Contractor prequalification has been heavily documented in the literature. The regulations governing the bidding process in some DOTs prefer to allow all bidders to tender a proposal, and they evaluate bidder qualifications after the bid. Post-qualification procedures have not been discussed as extensively in the literature, but the limited information recovered suggests that most factors considered in post-qualification procedures are similar to those considered in prequalification. In addition to prequalification and post-qualification, Thomas and Smith (1994) report that all DOTs require performance bonds. While not all states required 100 percent bonds, the vast majority do. Those that do not use some form of qualification rely completely on the contractor's ability to provide a performance bond. Their view is that if a surety company is willing to support the contractor and issue the bond on the contractor, then that is satisfactory evidence to the agency that the contractor is qualified. Surety evaluations consider many of the same factors as DOT qualification systems. Moreover, there is a financial incentive to the surety to correctly evaluate the contractor's capabilities. A key advantage to DOT qualification is their ability to collect information regarding contractor performance on their projects, although the way in which this information is applied in the process of qualification is, in many instances, subjective. Because contractor licensing requirements and regulations vary widely, these are not considered to be an effective qualifying tool. Many licensing requirements are strictly a tax revenue device and have little bearing on a contractor's ability to deliver a completed project.

Several new techniques are currently being considered in public construction. Third party certification (TPC) using International Standards Organization (ISO) quality systems criteria focuses mainly on quality audits of the contractor's quality management system. Project audit systems that evaluate the final project quality are also found in the literature and will be described in more detail in this section. Prequalification practices will be discussed in greatest detail due to availability of information and the similarities found in some post-qualification systems and surety evaluations.

PREQUALIFICATION

Prequalification is not defined consistently and different views of what the process should include are evident in the literature. Nettleton (1948) describes prequalification as the determination of the responsibility of each contractor to satisfactorily undertake and complete a certain construction project before the issuing of plans, specifications, and proposals. It is an extension of the principle applied to the professions of law, medicine, and engineering in which persons must have a certain understanding of appropriate theory and applicable experience to be licensed for business. Others (Russell, 1996; Thomas et al., 1985) focus on a more deterministic process for evaluating the competence and responsibility of contractors before submitting bids. Russell, in particular, focuses on the screening of candidates on the basis of a set of defined criteria.

In terms of prequalifying contractors prior to their procuring construction contracts, contractors can be evaluated in several ways. Drew and Skitmore (1993) suggest that contractors be qualified solely on the basis of their historical record of being competitive with their bids; thus, they view the objective of prequalification as obtaining the lowest bid at the minimum bidding cost to the owner. Holt, Olomolaive, and Harris (1995) suggest past performance and quality as measures of client satisfaction for the objective of prequalification. Hauf (1976) focuses on disqualifying incompetent, overextended, and under-financed contractors. Diekmann (1981) identifies the four objectives of prequalification as limiting cost exposure, evaluating company stability, ensuring quality in the finished product, and evaluating management capability. Thomas et al. (1985) identifies three functions: minimizing adverse consequences of contractor default by carefully screening out financially and technically weak contractors maximizing the benefits of overall competitive bidding, and improving the quality of public construction work. No authoritative study was found that validated the use of qualification systems efficacy in meeting these criteria.

A responsible bidder can prove possession of satisfactory skill, knowledge, integrity, plant, equipment, personnel, and finances to undertake the work. A responsive bidder merely submits the appropriate bid information as requested by the DOT. Thomas et al. (1985) extended the concept of responsibility to include:

1. Financial strength and resources of the contractor.
2. Documented skill of the contractor and subcontractors on previous contracts.
3. Judgment which is extended to financial and construction management.
4. Overall experience in the construction industry, as well as experience of the key personnel who execute the work.
5. Integrity of the officers to ensure they have not been involved in previous wrongdoing or contract crimes.
6. Previous performance, which evaluates the contractor's quality of construction and ability to complete the project within the goals of time and cost.
7. Ownership of equipment or the ability to rent or lease equipment needed to perform the project.
8. Ability to perform in accordance with the contract.
9. Ability to acquire bonding from an established and reputable surety.
10. Conformity to the goals and objectives of affirmative action plans.

The primary objective of prequalification, therefore, is to discern the responsible and responsive contractors from those who are merely responsive. Quality is generally included as an element within the evaluation of a responsible contractor. Although the literature addresses the inclusion of quality in discussions of prequalification, specific suggestions concerning what is measured and how to measure it relative to quality have not been clearly addressed.

Prequalification is not purported to be a cure-all. The system has advantages and disadvantages that have been identified in previous work (Lower, 1982; Hauf, 1976; Nettleton, 1948, Russell, 1996):

Advantages

- Levels the playing field (on larger projects since large contractors may bid small projects but smaller contractors cannot usually bid large projects).
- Avoids selection of unqualified bidders.
- Ensures competent, successful parties.
- Eliminates unqualified parties, even though they can be bonded.
- Controls the number of bidders.
- Reduces the cost of bid solicitation.
- Significantly hastens evaluation and award process.
- Provides structure and discipline to the process.
- Protects contractors from being awarded work they are incapable of doing.
- Facilities bidding by quality contractors who might have been inhibited from submitting a bid because of competition from unqualified bidders.
- Improves ability to react quickly.
- Allows more time for investigation of the contractors.
- Removes low cost bias.
- Reveals contractors who may be unable to perform due to backlogs.

Several advantages found in the literature refer to prequalification rejecting unqualified contractors, incompetent parties, and bonded unqualified parties. While this is certainly a possibility, no data or evidence was provided in the literature to support these claims. Thus, literature-based claims of prequalification system performance advantages appear to be subjective claims, not factual. Efforts to locate current published statistics on DOT contract default rates compared to the general default rate of bonded contractor, to validate the claim, were not successful.

Disadvantages

- Factual determination of responsibility is difficult.
- Additional screening is a burden on the contractor and creates workload for the DOT.
- Qualified contractors may choose not to participate.
- Developing, implementing, and evaluating objective criteria are costly.
- Difficult to formalize decision process without introducing subjective judgment and biases.
- Potential for biased or erroneous denial of admission into bidding process.
- Limits contractors' ability to expand into new areas in which there is no prior experience.

Of these factors, the most problematic would be the use of subjective data that is used in the determination of the contractor's eligibility, particularly if it results in an erroneous denial of admission into the bidding process. Many DOTs collect subjective information for the purpose of evaluating performance but tend to loosely word their administrative procedures for using the information collected.

Capacity Ratings

Maximum capacity ratings are used by some DOTs that prequalify contractors. This is the maximum dollar value of work that a contractor may have on the DOTs books at any given time. This rating is also known as the “bid ceiling,” “bid cap,” or “bidding capacity” and can control whether or not a contractor can bid on or be awarded a project. Work quality can also be considered as an element in evaluation of the maximum capacity. Many DOTs do not use past performance or quality data as a condition for determining their capacity rating. Factors considered in typical performance ratings are the contractor’s organization, personnel, prosecution of the work, construction equipment adequacy, and prior relationships with the owner and the public. Quality, where indicated on one particular performance rating, accounted for only 5 percent of the total weight, while questions about the contractor’s equipment accounted for 35 percent. Thus, with a few exceptions, there is little support for the concept that quality is being used in determination of capacity ratings.

Ratings for Other Factors

Vendor quality can often impact the contractor’s performance, and, potentially, it could impact project acceptance. Vendor selection, with a few exceptions, is within the contractor’s control and could be included in the measurement scheme. One element that significantly influences a contractor’s performance is the quality of the design. Pedditnti (1993) discusses linear weighting and more advanced mathematical models as a quantitative approach to selection of vendors, as well as cost analysis, lot rejection analysis, and weighting of quality characteristics. Diekmann (1981) proposes applying utility theory concepts to prequalification. Experience with utility theory suggests that the utility models would be complex and difficult to validate among the various agencies. Russell and Ahmad (1990) present a probabilistic model for approximating a normal distribution. A contractor’s rating can be based on confidence interval approximations. A poor quality design and DOT supervision impacts should also be considered as factors when judging a contractor’s performance rating; however, little was recovered in the literature that identified processes or potential procedures to accurately perform this evaluation for DOT contracts.

Bonding and Prequalification

Russell (1990) and Nettleton (1948) both suggest that using bonds alone does not guarantee that a contractor can perform the work. Bonds protect against financial losses but cannot predict delays and public inconveniences. In addition, nothing in the literature suggests that prequalification predicts delays, eliminates public inconvenience, or guarantees that contractors can perform work. The value added by a prequalification system, from the prediction standpoint, is that DOTs collect performance information on contractors. Assuming that these can be used for trend analysis, it would be reasonable to project a contractor's tendency to finish behind schedule. Other DOT inspections will reveal if the contractor is capable to perform work in a technical sense but also requires additional information to evaluate other performance capabilities. Surety companies can do a great deal to evaluate performance, but they lack the intimate knowledge of contractor operations that can be obtained by the DOTs.

DEPARTMENTS OF TRANSPORTATION

Inspection of agency processes defines the current practices used for contractor performance evaluation. DOTs were requested to send all information on their methods of contractor qualification, contract bidding, and the rating of contractors' past performance. Responses were received from 35 agencies and the Ontario Ministry of Transportation. Follow-up phone and personal interviews were conducted with DOT officials from those agencies that appeared to use innovative methods. The team also acquired additional supporting documents from some of these states.

The following list includes the predominant factors considered by DOTs in their qualification procedures:

- Financial statement of the contractor including equipment inventory.
- Years in business and years experience as a general contractor.
- Details on major projects completed (most require 3-5 years of data).
- Details on projects in progress.
- Experience of personnel.
- Failure to complete projects.
- Employee failure to complete projects.
- Disqualification or failure to be pre-qualified.
- Work quality based on post-project reports.

While each of these factors can be related to the contractor's ability to perform the work in the project, only the last factor has a bearing on the quality of the work in place. Table 2.1 is a summary of respondent states showing their primary qualification process and performance rating system criteria.

Many of the performance rating systems currently in place use a questionnaire. Key elements in the current performance measurements by the departments are the contractor's cooperation, schedule and product. A few states are already using an indexing system to rate or rank contractors and are noted in the table. The following sections on specific agency practices were chosen because their practices were unique in terms of the process used to evaluate contractor performance.

Ontario Performance Evaluation Factors

Ontario has proposed using contractor performance based on test results for qualification and, where the contractor fails to comply with specifications, procedures, conditions and standards, the contractor's adjusted rating may be reduced by an amount calculated as a percentage of his Basic Rating. Ratings are the amount of contract dollar volume a contractor is permitted by the agency. The amount of reduction is based on:

1. Withdrawal of tender by low bidder.
2. Failure to start on time, maintain schedule, and complete on time.

Table 2.1. State-by-state synthesis.

	AK	CO	CT	DE	FL	GA	ID	IL	IN	IA	KS	KY	LA	MA	MD	ME	MI	MN	MO
PRE-QUALIFICATION	X	X	X		X	X	X	X	X	X	X	X	X	X			X		
POST-QUALIFICATION																			
LICENSE	X				X		X						X						
INCENTIVES																		X	
CYCLICAL CONTRACTOR PERF. RAT.																			X
PAST PERFORMANCE																B			
PROCESS																			
-Cooperation			D	D		D		D	D	D	D	D		D	D	B	D		D
-Equipment	C	C		D	D	B		C	B	B		B		B			D		D
-Organization &Management		C		D	D			B	B	B		B		B		B	D		D
-Schedule			B	D	D	D		D	D	D		D		D		B	D		D
-Timely Submission of Reports			D		D				D					D	D	B			D
-Safety				D		D										B			
-Job Cleanliness			D		D														
-Experience																			
-Past Projects	C	C			B	C		C	B	B	C	B		C					
-On-going Projects	C				B	C					C	C							
-Default	C	C				C		C		C	C								
-Pre-Qualification in Other States											C								
PRODUCT				D		D		D	D	D	D	D		D	D		D		D
FINANCE	C	C			C	C		C	C	C	C	C							
CURRENT INDEXING SYSTEM		M													X				

X: Yes
M: Materials only
C: Contractor fills out self-report
D: DOT evaluates contractor
B: Both

Table 2.1. State-by-state synthesis (continued).

	MT	NE	NJ	NY	NC	ND	NV	PA	SC	SD	TX	UT	VT	VA	WA	WV	WI	WY
PRE-QUALIFICATION		X	X		X	X	X	X	X		X	X	X	X	X	X	X	X
POST-QUALIFICATION				X														
LICENSE					X	X			X									
INCENTIVES																		
CYCLICAL CONTRACTOR PERF. RAT.										X								X
PAST PERFORMANCE																		
PROCESS																		
-Cooperation		D			C		D	D			D	D	D	D	D	D	D	D
-Equipment		D	C	D	C	C	D	B	C			D	D	C	B	D	B	B
-Organization &Management		B			C		D	B	C	D		D	D	D	B		D	D
-Schedule		D	D		D		D	D		D		D	D	D	D			D
-Timely Submission of Reports			D									D	D		D			D
-Safety		D					D											D
-Job Cleanliness																		D
-Experience																		
-Past Projects		C	C	C	C	C	C	B	C	D		B	C		B	C		C
-On-going Projects				B	C	C	C		C					C				C
-Default		C	C	D			C	C	C				C		C	C		C
-Pre-Qualification in Other States		C			C								C			C		
PRODUCT		D			B		D	D					D		D	D	D	D
FINANCE		B	C	C		C	C	C	C		C	C	C	C	C	C	C	C
CURRENT INDEXING SYSTEM					X		X					X				X	X	

X: Yes
M: Materials only
C: Contractor fills out self-report
D: DOT evaluates contractor
B: Both

3. Failure to discharge liabilities.
4. Failure to comply with other contractual conditions or specifications.
5. Inadequate organization, cooperation, or personnel.
6. Failure to provide satisfactory equipment.

Their initial reduction factor is gradual, based on fixed percentages:

1. Has not done work related to this road authority – 70 percent.
2. Has never had a prime contract – 70 percent.
3. Has demonstrated work for another road authority – 40 percent.
4. Had done related work, but not as classified in current work – 40 percent.

Reductions help to adjust allowable contracting volume, reducing agency risk, while permitting a contractor to gain the requisite experience to function at 100 percent capacity.

<u>Maryland</u>

Although the Construction Section of each district in the state annually rates all contractors who worked in their district in the past year, Maryland does not tie the grade to a bid ceiling or bid limit in any way. The Project Engineer who oversaw the project performs the ratings. All ratings for a particular contractor are tallied and averaged, giving the contractor one grade for the entire state.

The numerical grade is between zero and one, and is a function of nine factors:

1. Competence of Personnel.
2. Public Relations.
3. Quality of Work.
4. Overall Administration.
5. Cooperation.
6. Adherence to Safe Practices.
7. Sub-contractors.
8. Equipment.
9. Contract Time.

Each of the factors has between one and seven sub-items to consider and is rated between one and ten and then multiplied by its weight to derive the numerical grade of between zero and one. A letter grade from A to F is then assigned each contractor based upon the numerical grade. This approach is similar to scholastic grading scales.

The numerical grade for each year is averaged with the three previous years to give a more stable grade over a longer period. Individual data are then compared to the averages to identify trends and the entire four-year period is plotted to check for trends. The individual projects are plotted against the average to check for bias on the part of the district or any project engineer. A contractor's ratings may be analyzed to compare performance as a subcontractor to performance as a prime. Each year, every contractor who did work in Maryland gets a 'Report Card' which provides the contractor's numerical grade for that year, the numerical grade for the four-year period, and the state-wide average for each of those time periods.

One of the incentives for contractors under this system is a waiver of the normal 5 percent retainage. If a contractor begins a job with a letter grade of 'A,' then after 3 months have elapsed on the contract they may petition the state for a review of work accomplished. The Project Engineer will then grade the contractor's performance up to that point on the project. If the contractor still has an "A" grade, then the 5 percent retainage is waived for the project.

If the apparent low bidder on a contract has a current grade of 'D,' then that contractor is summoned to the DOT office, where the contractor's credentials and capacity to perform are challenged. The state has a contractual right at that point to reject submitted bids if they are not satisfied that the contractor can do the job. If the contractor is awarded the contract, then the retainage can be raised as high as 10 percent for the project. Maryland has not failed to award a contract to a prime contractor based on a grade of 'D,' but retainage has been raised to 10 percent on occasion. Several subcontractors with 'D' grades have also been rejected. Only one contractor has ever received a grade of 'F,' and that contractor was never the apparent low bidder during that period of time. No challenges to the grading system are known.

Wisconsin

The Project Manager rates the prime contractor and each subcontractor at the time of contract completion or, if necessary, when a subcontractor's work is completed. The Overall Rating is a function of six factors:

1. Quality of work.
2. Prosecution and progress.
3. Supervision.
4. Cooperation/contract compliance.
5. Adequacy of work force.
6. Adequacy of equipment.

Each of the six factors has a list of between three and eight sub-items to consider, and each factor is rated and multiplied by an 'Importance Factor' to derive a 'rating.' The rating for each factor is summed to generate an 'Overall Rating' from zero to ten.

The primary purpose of the rating is to provide input when establishing a contractor's bidding limit. The bidding limit is determined by multiplying a 'Financial Factor' (taken from prequalification documents) by a 'Work Factor' (an evaluation by the DOT as to the quality of the work being performed by the contractor). The generation of the work factor includes referencing the six-factored rating mentioned earlier, but the two are not tied together procedurally. A secondary purpose is to monitor extremes in contractor performance. Contractor bidding limits have both increased and decreased based upon this rating. This state is adamant that prequalification based on any criteria is a waste of time and that post-qualification is an equal waste of time.

North Carolina is emulating the Wisconsin system, but they intend to tie the field rating to their ‘Construction Quality Index,’ which is an equivalent measure to Wisconsin’s ‘Work Factor.’

Utah

The Utah Department of Transportation (UDOT) is currently developing a new contractor rating system, which will consist primarily of a list of questions to be answered by the UDOT project engineers. Each of the questions, which relate to contractor project performance, can be answered “Yes,” “No,” or “NA.” The concept is to evaluate contractor performance based upon these ratings of basic project activity. Consider, for example, the following typical questions:

1. Did the contractor have the right equipment to perform the work?
2. Did the contractor start the work on time?
3. Did the contractor respond quickly to the Public’s needs?

There are currently 76 questions covering a wide range of performance categories including project management, timely scheduling, reporting and documentation, EEO and DBE compliance, training program compliance, installed work quality, subcontractor supervision, and contract claims. UDOT assigns a weight of one point to each question. The contractor’s score would be the total points received for positive answers. They are also considering applying a Project Difficulty Factor, which would adjust the Contractor’s score based upon the relative difficulty of the project.

UDOT plans to have the Project Engineer review the evaluation questionnaire with the Contractor several times during the performance of the project, not just at the conclusion. This should improve DOT-Contractor communications and facilitate addressing deficient performance promptly.

The Utah approach removes a measure of subjectivity from the evaluation process. Yes/No answers to basic questions on project activity are used to define the contractor’s performance. As with any questionnaire, the questions must first be tested with different personnel to insure consistent interpretation. With refinement, however, the questionnaire approach should contribute to the goal of a fair and consistent contractor evaluation.

Breaking down the performance evaluation into specific items should improve consistency of measurement from project to project. Also, from an organizational management perspective, both the owner and the contractor should benefit from the additional level of detail in the evaluation. Problem areas requiring increased management attention can be identified.

Virginia

The Virginia Department of Transportation (VDOT) uses a two-factor qualification system that employs the use of a performance questionnaire score in the determination of the contractor's bidding capacity. The C-36 form referenced below is the DOT's questionnaire evaluation of the contractor's end of project performance. The VDOT capacity formula is as follows:

$$[(C_A - C_L) + (N_A - N_L)(0.60)] A = \text{Maximum Capacity}$$

C_A = Current Assets
C_L = Current Liabilities
N_A = Non-current Assets
N_L = Non-current Liabilities
$A^* = \dfrac{\text{Summation of last 24 months C-36s}}{\text{(number of C-36s) x 100/12}}$ (*based on a minimum of five (5) form C-36s)

The interim project report and final project report are divided into four categories as follows:

- Prosecution of Work
- Project Communication
- Safety
- Environmental

There is room for the reviewer to comment on each category on the back of the scoring sheet. The final report includes a report on previous interim reports filed for the project. The interim reports are given a 70 percent weight factor in the final project evaluation. The District-level evaluation focus is on the same four areas but on more global issues in the contract. The District evaluation is given a 30 percent weight in the final evaluation. The questionnaire is fairly open in terms of specific question weights. Total points are constant, but the reviewer has discretion on point distribution to each question. Bonus points are also possible for contractors who exceed expectations.

The use of two related questionnaires, one for the project level issues and the other for the final evaluation, incorporating District input, is unique. The use of interim reports to track the contractor's project progress provides the contractor an opportunity to improve some elements of their performance during prosecution of the work.

Connecticut

The State of Connecticut Department of Transportation conducts annual performance ratings of all contractors, including subcontractors, for a calendar year. Interim ratings are used to evaluate a contractor's performance on a project to date and are conducted only when requested by the Offices of Construction or Contracts. The Connecticut questionnaire has five elements as follows:

- Quality of Work.
- Performance of Work.

- Adherence to Project Schedule.
- Implementation of Federal, State, and Local Policies, Procedures, and Regulations.
- Procedural and Administrative.

The first category, quality, is a single question with a maximum value of 4 for excellent. Other categories contain 4 or more questions, not all are required responses, and the average is taken for the section. An interpretation key is provided to give the evaluator a guide on each question's response possibilities. The primary use of the information is in determination of responsibility questions. The data collected by the Department is not unlike many other performance rating systems. It is not used in direct calculation; rather it is available for decision support. Their process is mentioned here because of the trend data they have retained from the surveys.

The distribution of ratings from 1993 to the present reveal few ratings that in a four year period many contractors only performed work on a single project. Of the 430 contractors in the database, more than half only had a score for one project. There was no obvious pattern that these one-time contractors performed any better or any worse than 'regular' contractors. Without performing any sophisticated evaluation, the data clearly support the contention that good contractors perform consistently well. Poor contractors perform at a relatively consistent poor or below average level.

<u>West Virginia</u>

The Secretary of State’s Office oversees a program set up by state legislation called the West Virginia Contractor’s Licensing Law to Support Quality Construction. Before a contractor can prequalify for work with the Division of Highways, that contractor must first have a license issued by the Secretary of State. This license is issued based upon the following criteria:

1. Payment of Bills.
2. Payment of Taxes.
3. Payment of Worker’s Compensation.
4. Adherence to Davis-Bacon pay scales.
5. Experience in the type of work licensed.

The Division of Highways oversees a traditional prequalification procedure based primarily upon a financial questionnaire and inquiry into bonding and equipment information. They have no formal contractor’s performance rating system.

<u>Minnesota</u>

In an alternate approach to achieving the goal of quality construction, Minnesota bases their entire transportation-building program on a system of incentives and disincentives. Minnesota awards contracts based upon a low bid and with a full performance bond and a full payment bond. Typically incentive contracts reward a contractor for achieving better than specified quality levels or will penalize for less than specified quality levels. The motivation for the contractor is earn the additional incentive. The philosophy establishing an incentive program is important to consider. Some view incentive payouts as a waste of money when the contractor has, but signing bid forms, agreed to construct according to specifications. Others view the opportunity provided by incentives to drive quality higher than that specified. The discussion below describes the evolution of the Minnesota incentive program.

Approximately ten years ago, The Minnesota Department of Transportation (MinnDOT) offered incentives for ride quality, hoping to improve the quality in that area of their construction program. At first, the incentives were only offered for smoother rides on concrete pavement. Later, bituminous paving was added to the incentive/disincentive program. The plan was to test each project with a California Profilograph and reward or penalize contractors according to set criteria. MinnDOT officials were encouraged as they watched contractors purchase new and better equipment to assist them in garnering the incentive money. Ride quality rose dramatically.

Approximately five years ago, the program was extended to include other areas of construction. Concrete was the first area to be added to the program, with compressive strength as the measuring stick. Unfortunately, there was too much disagreement among the parties involved as to how and when to measure the strength. The state decided to change the measure from compressive strength to water/cement (W/C) ratio. This has worked very well, as the statewide average W/C ratio has fallen 17 percent since the program was implemented.

At approximately the same time, aggregate-quality bonuses went into affect. This incentive was offered in order to lower alkali content in the course aggregate and achieve more uniformity in the aggregate size, as gap-grading had been a problem. MinnDOT is very happy with the improvement shown in this area also.

Recently, with the advent of Superpave, attention has again turned to bituminous paving, specifically to achieving higher density in the asphalt mat. To this end, density specifications were used to formulate an incentive program for asphalt density. The results have been extremely encouraging. Knowing MinnDOT's commitment to its incentive program, contractors immediately bought better compaction equipment.

Contractors have become innovative in their pursuit of incentive money. Large rubber-tired traffic rollers were being used as breakdown rollers. This technique has been long debated by bituminous engineers, and long resisted by contractor advocacy groups due to the initial cost involved. Contractors in Minnesota have discovered ways to remedy each of the problems associated with the technique, and have improved statewide asphalt mat density over one percent on average since the implementation of the incentives. One percent is considered a very significant increase.

Minnesota officials warn that, when implementing a program such as theirs, a state must realize that for the first two years or so costs will remain higher because, they are basically buying new equipment for the contractor. After that period, however, bids will start to come down as the contractors, knowing that the incentives are achievable, start adjusting bids accordingly. Thus, contractors who can consistently achieve the higher performance standards could theoretically improve their bidding success.

Data from MinnDOT indicates that, at this point in their experience, three percent is the key figure for their overall program. The DOT pays out approximately three percent over the bid amount on an average contract. The contractors, on the other hand, are submitting bids approximately three percent lower than when the program was first implemented. This would seem to indicate that Minnesota is getting better quality for approximately the same price.

Colorado

The Colorado Department of Transportation Report No. CDOT-DTD-R-98-4, entitled Hot Bituminous Pavement QC & QA Projects is based on projects constructed in 1997 under QPM2 Specifications (Cramer et al., 1998). This publication details a rating system for contractors' use of materials and the quality of those materials in the area of asphalt paving.

The authors of this publication have attempted to rate the quality level of every contractor who did work for the State of Colorado in 1997. The ratings were based on test results. The publication lists both the overall quality level, in the form of a grade or index, and the percentage of each contractor's work that fell beneath a grade of 65. The contractor's identities were coded in the publication. In addition to quality scores, incentive and disincentive amounts were listed for each contractor. The rating tables were extended to cover a 5-year evaluation period.

The most interesting conclusion by the report author was that 'The better performers repeat year after year, and likewise, so do the poor performers. Apparently the incentives and disincentives are not enough to persuade some contractors to produce at a higher level. Competition will not always guarantee the most efficient contractors will be the lowest bidders.'

Missouri

The Missouri Highways and Transportation Commission (MHTC) have been engaged in development of a performance ranking system for highway construction projects. Starting January 1998, a new questionnaire rating system replaced their subjective performance evaluation system that had been in place since 1991. The contractors were participants in the development of the questionnaire system. The MHTC specifications were the guiding format for the evaluation system.

The questionnaire is divided into sections corresponding to their specifications. Point values are assigned to each question. Each question is assigned to one of four categories: Quality, Prosecution and Progress, Contract Compliance, and Safety. See Table 2.2 for the specification sections in the questionnaire and distribution of questions according to he categories. Not all questions in the questionnaire would be applicable to all projects. Category performance is determined from total points scored on applicable questions. Achievement in each category is weighted according to the predetermined weighting scheme or importance factors as follows: Quality, 30 percent; Prosecution and Progress, 30 percent; Contract Compliance, 20 percent; and Safety, 20 percent. The contractor's overall performance is a weighted average on the basis of each contract's value.

Table 2.2. Missouri DOT Questionnaire Framework.

Section	Title	No. Questions by Internal Division			
		Contract Compliance	Prosecution/ Progress	Quality	Safety
100	General Provisions	18	8		
200	Earthwork	5		6	1
300	Bases and Aggregate Surfaces	1		10	
400	Flexible Pavements	3		9	
500	Rigid Pavements	2		9	
600	Incidental Construction	2		9	7
700	Structures	3		17	1
800	Roadside Development	4		4	
900	Traffic Control Facilities	2		3	

Contractor performance is then placed into one of five categories: Outstanding, Above Average, Average, Below Average, and Unacceptable. These categories are determined from the annual data reported for all contractors using a Normal Distribution. The plus- and minus-one-standard-deviation range is considered the average range. Between plus one and plus two standard deviations, the contractor would be rated as Above Average. Any score greater than two standard deviations above the mean would rate the contractor's performance as outstanding. Similarly, the below average and unacceptable ratings are determined by the mean-minus-one and minus-two-standard-deviations respectively. The contractors are rated annually in each of the questionnaire categories and overall. A contractor who has been given an unacceptable rating is placed in a probation category. If the following year's rating is also unacceptable, the contractor is suspended for a period of one year. After their suspension the contractor is permitted to bid projects in a probationary status. A contractor in this probationary category who, at the end of the year, is again rated unacceptable is suspended for a period of three years. The department also recognizes contractors who achieve superior performance ratings. The contractors are divided into four groups. The first three groups are based on contract dollar volume and the last category is specialty contractors or those who perform 85% or more of their work in a single specification area.

In 1999 the MHTC evaluated 111 contractors on 334 projects. Two contractors who should have been placed on suspension were given an addition year of probationary status due to changes in the evaluation process. Eleven contractors were placed on probationary status and three were returned to good standing. Top achievers in 1999 for overall and each questionnaire category were recognized with plaques at the Annual Resident Engineer's Luncheon. Having a brass plate displayed in the lobby of the MHTC's support center also recognizes the top overall achiever in each group. A copy of the most recent MHTC questionnaire is provided in the appendix of this final report.

DOT processes for encouraging quality improvement have the same goal as some systems developed in private industrial construction.

QUALITY PERFORMANCE MEASUREMENT SYSTEM (QPMS)

The early efforts in categorizing and quantifying quality performance on industrial construction was reflected in research on containing the level of rework on a project and tracking the source of the rework. Since those pioneering efforts, other researchers have developed more refinements to QPMS. The Construction Industry Institute research is focused on what is termed EPC (Engineered-procured-constructed) project. Necessarily the main concern is on delivery of customer satisfaction with design and commissioning. Their decade-old effort has produced the following reports:

- Costs of Quality Deviations in Design and Construction (1987)
- Measuring Design and Construction Quality Costs
- Quality Management Organizations and Techniques
- Cost of Quality Deviations in Design and Construction (1989)
- Measuring the Cost of Quality Deviations in Design and Construction (1989)
- The Quality Performance Measurement System: A Blueprint for Implementation (1990)
- Total Quality Management: The Competitive Edge (1990)
- Guidelines for Implementing TQM in the Engineering and Construction Industry (1992)
- Quality Performance Measurements of the EPC Process: Current Practices (1992)
- Adaptation of Quality Functional Deployment to Engineering and Construction Project Development (1993)
- Implementing TQM in the Engineering and Construction Industry (1994)
- Measuring Quality Performance on EPC Projects (1994)
- Quality Performance Measurements of the EPC Process: The Blueprint (1994)

Figure 2.1 is a general concept of the process flow for determining the elements to be used in the QPMS process on an EPC project. (From SD103)

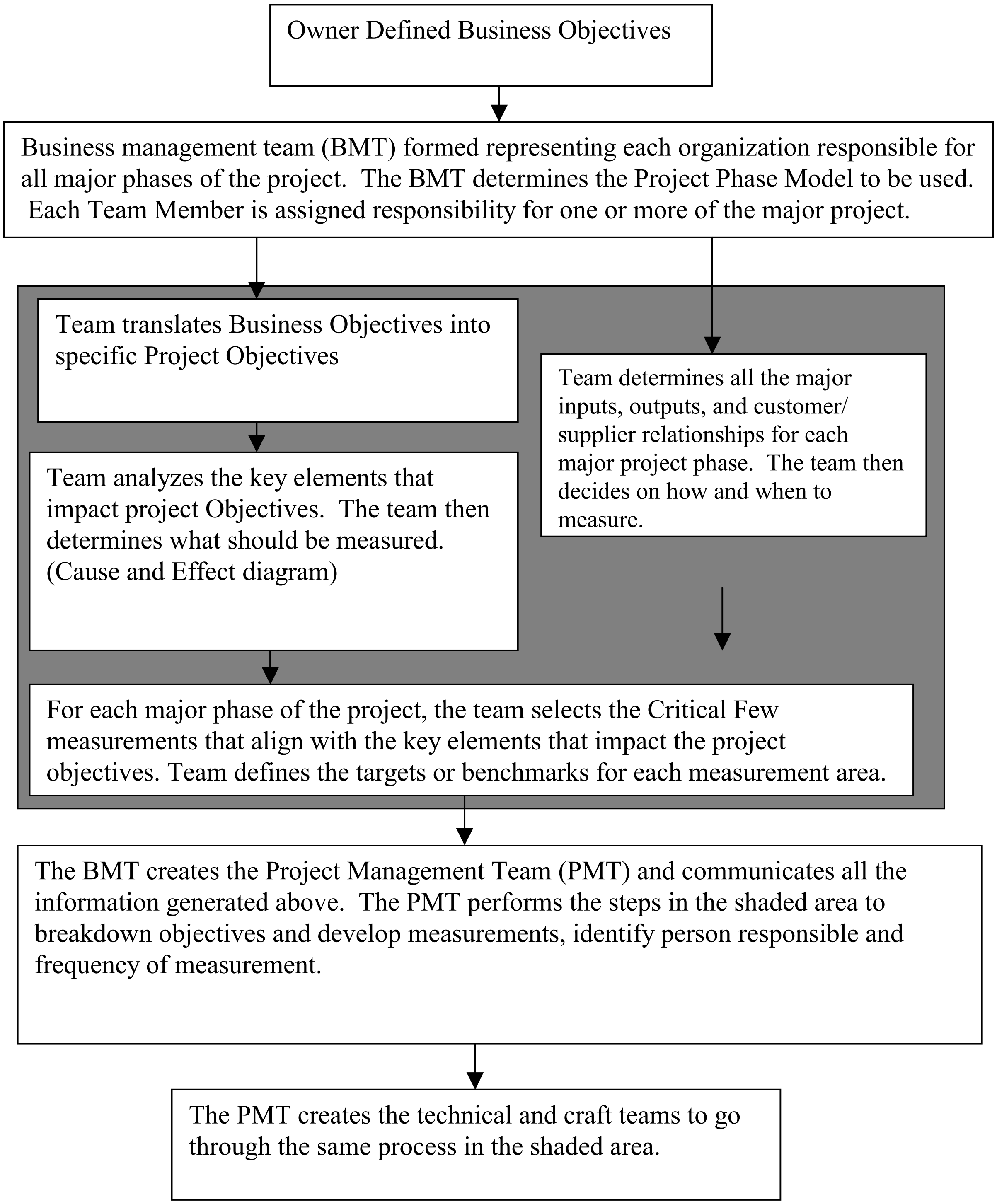

Figure 2. QPMS Process Flow Diagram.

Overall QMPS has effectively evolved greatly from its early efforts on quantifying the cost of quality via rework.   The four main areas of the QPMS quality matrix include: Customer focus, Leadership, Delivery and Employee Empowerment. Major elements of the quality performance measurements matrix are in the following outline:

I. Customer Focus
  A. Evaluation
    1. Performance
    2. Satisfaction
    3. Incentives
  B. Communications
    1. Feedback
    2. Planning
  C. Responsiveness
    1. To requirements
    2. For improvement
II. Leadership
  A. Strategic Visioning
    1. Information Sharing
    2. Instructions Procedures
    3. Organizing
    4. Process Mapping
    5. Quality Planning
  B. Tacktical Resource Deployment
    1. Information Sharing
    2. Organizing
    3. Prequalifying
    4. Process Mapping
    5. Instructions/Proceedures
  C. Involvement
    1. Information Sharing
    2. Instructions/Procedures
III. Delivery
  A. Cost
    1. Bechmarking
    2. Cost
    3. Utlization
    4. Technology
  B. Time
    1. Benchmarking
    2. Schedule
    3. Utilization

C. Safety, Health, Environmental
    1. Safety
    2. Health
    3. Environmental
D. Product Deliverables
    1. Benchmarking
    2. Statistical Reasoning
    3. Quality Losses
    4. Resource Utilization

IV. Employee Empowerment
A. Teamwork
    1. Teaming
B. Tactical Resource Deployment
    1. Goals
    2. Objectives
    3. Procedures
C. Training

The management process described in the process figure directs the selection of various types of measurement schemes for projects to use. The customer focus section contained a number of 'report card' feedback tools and assessment tools similar to those used by DOT post-project evaluation questionnaires. The contents from one such report card follows:

- Understands and Translates Customer Needs into Requirements.
- Manages Schedule.
- Controls Cost.
- Delivers Technical Quality.
- Safety/Health/Environmental Issues.
- Communications.
- Work Process.
- Administration.
- Interpersonal Relations.
- Leadership.
- Subcontracts/Major Suppliers.

These are scored from 1 to 5, with 1 representing "fell short of expectations" and 5 representing "exceeded expectations". Various other tools similar in content were included as tools that could be included in an overall program depending on the project objectives as described in the flow chart above.

Further investigation of the delivery section included tools to:

- Determine productivity of engineering effort.
- Control individual work packages.
- Identify leading causes of rework.

- Determine nonconformance by project element.
- Evaluate engineering design performance against objectives.
- Identify deviation costs by area.
- Compare root cause and initiating discipline of rework.

Under the subject heading of 'tactical resource deployment,' one sub-heading was prequalification. The vendor and contractor prequalification forms provided in the QPMS are generic qualification forms requesting information on the contractor past activity and provides no analysis or measurement of contractor performance, other than standard references for telephone research on past activity. The 'system' aspect of QPMS is the organization of a diverse group of existing measurements for reference purposes. Since management teams would change and supposedly the make-up of the QPMS for the next project would also change, comparison and ratings based on a number of projects would be difficult. No such process was described in the materials reviewed.

EXTERNAL RATINGS AND CERTIFICATIONS

One possible method to assure that only recognized 'quality contractors' work on DOT projects is to specify an external quality management system certification standard, like certifications required for material testing laboratories. One such external certification for management systems is ISO 9000. Another approach is the third-party audit process used in Singapore called CONQUAS. Each of these external or third-party evaluations will be described.

ISO 9000

Like manufacturing companies, constructors translate user-defined requirements established in the design and specifications into products. Unlike manufacturing, the public sector often separates development of the design and specification requirements. In many cases independent consultants prepare the design based on standardized design procedures, and the DOT prepares the standard specification modifications for the project. Standardized design requirements and standard specifications do, in many regards, reduce the large number of variables that could contribute to poor quality. However, even with this amount of standardization, design quality seems to be highly variable.

One international quality standard has been developed and implemented through the International Standards Organization (ISO). ISO was founded in 1946 to develop a common set of manufacturing, trade, and communication standards. The American National Standards Institute represents the United States. All ISO standards are voluntary compliance standards. As the standards are presented in detail, however, their applicability to construction is apparent.

Some other distinguishing characteristics of construction are important to consider. ISO 9000 and similar standards are often developed with industrial applications in mind. While construction and industrial production do have some similarities, there are some large differences. Industrial project teams are often from various departments of an industrial operation (a single culture environment) and typically control all major aspects of the process, including design. Construction products are always unique to some extent. Construction project teams are created from representatives of companies who are coordinated through separate contracts to produce a construction product. The project teams and employees are recreated for each project. Not only are the company cultures different, each team is uniquely arranged. In the United States, competition is based purely on competitive pricing (market share or service delivery capabilities are not measured for contractors). Service capability is the primary criteria for selection of DOT design consultants.

ISO 9001 was reported as being used contractually on infrastructure projects in Europe (roads and metros), Africa (water supply and waste treatment), and the Far East (roads, railways and airports) as a model for project quality systems driven by owners. Documented quality systems are used, audited, and improved by project teams to reduce the cost of meeting the needs of those who finance, will use, and be affected by the project. Owners intending to prequalify must give the construction industry time to assess and upgrade, as necessary, their quality systems to meet the American National Standard (ANSI/ASQC Q9001 or Q9002). (Broomfield, 1995) Although reported as such, no further evidence could be found that the implementation of ISO was a project qualification requirement or the quality assurance process bid for that particular project.

The ISO system requires that external audits of quality systems are performed prior to certification, and that periodic reassessment is conducted to assure the certification is valid. This would effectively add a third layer of assessment on projects. The contractor, in checking their quality and inspection procedures, conducts the first level of quality assessment. The second level of assessment conducted is generally the assurance or inspections conducted by external parties (consultant inspections, or DOT inspections) who perform detailed examination of the product or service provided. The ISO requirement involves the third level assessment by an external examiner on the entire contractor organization for quality.

The ISO 9000 series standards cover primary quality system elements as follows:

- Management Responsibility.
- Quality System Principles.
- Auditing the Quality System (Internal).
- Economics – Quality-Related Cost Considerations.
- Quality in Marketing (Contract Review).
- Quality in Specification and Design (Design Control).
- Quality in Procurement.
- Quality in Production.
- Control of Production.
- Material Control and Traceability.
- Control of Verification Status.
- Product Verification (Inspection and Testing).
- Control of Measuring and Test Equipment.
- Nonconformity (Defect procedures).

- Corrective Action.
- After Sales Servicing.
- Quality Documentation and Records.
- Quality Records.
- Personnel (Training).
- Product Safety and Liability.
- Use of Statistical Methods.

The above areas must be addressed, if appropriate to company activities, in the quality management system manual. This is the major element of identifying at every level the quality management effort. The quality manual is supported by other company information like procedure manuals, division manuals, policies, objectives and organizational elements. Each process the company uses requires a standard process operation definition, procedures, and quality plan. Work instructions, instructional and training materials, forms, specification sheets, data sheets and other master recording documentation support another level of documentation.. The following table is adopted from Schlickman (1998).

The tiers explain how documentation requirements 'roll-up' from one level to the next. However another way to examine some of the documentation is provided in Table 2.4. Selected element documentation requirements are explained in better detail to give the reader an appreciation of the level of documentation effort satisfying ISO requirements.

One article reported the average manufacturing company cost of ISO 9000 implementation in excess of $245,000 (ASQC, Quality Progress, October 1995, page 69). In manufacturing each business location achieves its own certification. Contractors with multiple offices need to certify each primary office's compliance. Further examination of the cost did not reveal articles that suggested an average cost for implementation. However, many discussed the cost of implementation as a barrier to ISO implementation, unless it has been dictated as a cost of compliance for obtaining work. Another article on a Canadian contractor with ISO 9002 certification was published in *Roads and Bridges* (July, 1998). The Dufferin Construction Company reported that they adopted ISO 9000 to reduce their costs by using the stringent measurements and testing required in the ISO standards. The reduced rework has had the greatest benefit. Their unusual edge in some regards is absolute control over the concrete paving operations from batch mix production controls through placement and curing. The implementation of ISO 9000 also requires that ISO suppliers and vendors be used in products produced or their quality standards be nearly the same. In this illustration the contractor was its own supplier of concrete. Other contractors relying on vendors to supply will not likely have as much material control success. The article does give a clear demonstration that ISO 9000 registration is not out of the question for heavy and highway contractors.

Table 2.3. A Four-Tier Approach to ISO Documentation.

Tier	ISO 9000 CATEGORY	CONTENT	DEALS WITH
I	QUALITY POLICY MANUAL Quality Policy Statement Management review records	A time-independent document describing the organization's policies written in conformance with ISO 9000 standard model	The organization's response to each mandatory response requirement of the standard. The 'rules of the house' to ensure compliance and defined responsibilities
II	PROCESS DOCUMENTS & HIGH LEVEL PROCEDURES Standard Operating Procedures Business Plans	Time-dependent documents that describe either the overall processes of the organization or a combination of process and high-level procedures (contract review, design control, corrective & preventive actions).	Describes the purpose and answers what, when, where, how and who at a high level. Describes and details the flow of information from area to area, department-to-department, and building-to-building.
III	LOWER LEVEL PROCDURUAL DOCUMENTS Wall reference charts Instructional computer screens Test procedures Purchasing Procedures	Time-dependent, detailed step by step work instructions on how to complete a task. (At the operator or bench level). Can be integrated into Tier II documents.	Describes how to perform each job in a step-by-step fashion. Provides the necessary data to perform the tasks.
IV	UNFILLED IN FORMS OR FORMATS Templates Blueprints Schematics Data Sheets Specifications Drawings	Documents that specify the data requirements called out in the various documents or specific data sources. Many of the forms are used as (process) records once they are filled in, although specific records are required at all levels. Complementary documents to support work instructions.	The forms demonstrate that a procedure requiring either data taking or data-input was done. The templates required to measure and fabricate.

Table 2.4. Selected Documentation Requirements for ISO Elements.

ISO ELEMENT	TYPICAL DOCUMENTS	CONTENTS
4.1 Management Responsibility	Business Plan Security Manual Employee Manual	High level policy documents authored by company executives.
4.2Quality System Principles	Quality policy manual Process Master Manual Procedure Master Manual Forms Master Manual	Operational documents authored by company executives
4.3 Contract Review	Marketing Manual	All aspects of contract review and marketing
4.5 Document and Data Control	Document control system	QA, and engineering processes
	: :	
4.16 Control of Quality Records	Records Manual	Covers QA and engineering records.
4.17 Internal Quality Audits	Quality Audit Manual	Contains internal quality, vendor, customer, and third-party audit protocols
	: :	
4.20 Statistical Techniques	Statistical Analysis Manual	Sampling plans, Pareto charting, Statistical process controls etc.

Given the available information on ISO, the following synopsis of anticipated advantages and disadvantages identified by the researchers is presented.

Advantages in ISO Certification

- Ensures that at one point in time (during the certification audit) the contractor would be maintaining this type of quality management process (the system requires continuous process improvement and measurement).
- Would require every contractor in the industry to evaluate and document their processes and procedures related to every element of their operations. Increased standardization in procedures would likely result.
- Demonstrates the level of control the contractor maintains.
- Likely to reduce rework and some costly installation mistakes.

Disadvantages in ISO Certification

- Relatively high maintenance to manage and operate system.

- Requires significant investment of personnel and time.
- Level of training required.

<u>Unknowns Regarding ISO Certification</u>

- Would and ISO requirement provide value added to the DOT as well as the contractor?
- Does an ISO certificate provide sufficient evidence of quality performance to be considered mandatory for all contractors?
- What would be the overall effect of some DOT's adopting and others not adopting?
- Would requiring ISO result in reduced competition? Is it appropriate for all contracts?
- Challenges presented by DOT's prescribing how a contractor conducts business internally.
- Would it be reasonable for DOTs to also become ISO compatible with their systems?
- What time frame would be permitted for implementation?

The unknowns posed by the ISO systems are problematic than any of the disadvantages. These are hard issues to evaluate given the scarcity of information on contractors who have adopted ISO for public construction. The Utah DOT was contacted in regard to their use of ISO 9000 on the Interstate-15 project. They sent the following reply: "Our contractor, Wasatch Constructors, continues to maintain its certification. They had to do some work to get the original certification, but there have been minor findings on the recertification reviews. To answer your question of effectiveness, I think the measure is somewhat intangible, I'm sure there have been some aids to the project, but there are so many new things happening on the project, it is hard to measure."

<u>Contractor Quality Assurance Programs</u>

Third party certifications are one approach to having contractors maintain their own quality assurance process. Unfortunately, quality assurance and quality control mean the same thing to many people. Quality control focuses on checking product components and the finished work. Quality Assurance, on the other hand, focuses on the process of the work and the methods of evaluating the quality control process. This is the current standard of operation in the transportation industry. The traditional inspection process on highway or bridge construction projects is geared almost entirely toward inspection and testing of the finished work or elements of that work. The focus is on finding and fixing deviations from the plans and specifications. The most obvious elements of this final product inspection focus is the project punch list and final inspection processes. Corrective action for non-conformance is costly.

Contractor quality assurance, as a process, is a more structured approach to business management and quality control. Quality assurance enhances the contractors' ability to consistently provide products and services to specifications' requirements and cost. Thus, quality assurance includes the business process side of quality. In a *Quality Assurance Guide for Inside and Outside Electrical Contractors*, Glavinich (1995), suggests a number of key elements for a contractor's QA program. While some of the elements are specific to Electrical Contractors, the general principles of the QA process outlined are appropriate to all constructors. The contractor quality assurance process reported here and the elements of quality systems in ISO 9000 series standards are very similar. The element headings were adopted from the Glavinich publication and elaborated upon the context of transportation construction.

Design Management

With proper design management, an owner's needs and expectations can be efficiently converted into design drawings or shop drawings, and field quality and constructibility problems can be identified and resolved at minimum cost. That is the Florida DOT's goal with their Bidability/Constructibility Engineer and related staff. Many contractors, however, do not recognize their component contribution to the design management from shop drawings. Further, design-build contracts for construction require the contractor and design firm to be more involved in the management of the design process in conjunction with construction activities.

Construction Organization and Management

Responsibility for quality in the field must be clearly identified. Responsibility for workforce quality must be appropriate to achieve construction requirements. Just getting good people on the project may not be enough, especially if competency-based certifications are required in more and more areas of construction.

Safety and Accident Prevention

Safety is an integral part of project quality. Everyone agrees with this – or at least gives it lip service. A popular belief is, "If a contractor has correctly and thoroughly planned a project, and if the project is staffed with competent people, safety will take care of itself." Does each contractor need a proactive safety program, or is proper planning and staffing sufficient? The bottom line is that workers' should focus on doing the job correctly, not on the potential for injuries. Safety ratings of contractors are readily available as a measure of the contractor's safety and accident prevention program. Some safety ratings are biased for larger contractors, however, since they are based on the total number of hours worked.

Document Control

Receipt, recording, and dissemination of information to the proper personnel in a timely fashion is a key element of quality assurance. Assuring that proper personnel are notified of changes and provided with the most current documents can only be achieved by having a document control plan. Misinformation because of old specifications or drawings on the project site can create costly rework.

Procurement and Materials Management

Materials and installed equipment must meet the project's technical requirements. Though many of these processes currently have certification procedures conducted by the DOT, the contractor is still responsible for ensuring that the materials supplied meet specifications. Site inspections and plant material inspections are critical to contractor quality control efforts.

Tool and Equipment Management

Proper equipment is needed to execute the work. Equipment is currently examined as an element in most prequalification procedures, mostly from a value standpoint. The contractor must own or have sufficient access to proper equipment to perform the required work. Increased inspection and testing by contractors or vendors also requires calibration (field surveying instruments, laboratory test equipment, etc.) of all site equipment at proper intervals.

Construction Process Planning

The work plan requires that appropriate information, materials, and equipment are available when needed. Project- and activity-level planning are needed to correctly sequence activities. Proper sequencing ensures that appropriate resources are available and that the schedule is considered in the planning.

Inspection, Testing, and Start-up

Checking work in place has been the major quality function for many years. Contractor testing, however, is replacing the traditional level of testing conducted by the DOT. For many contractors, this carries a new responsibility that they make initial material acceptance decisions prior to assurance testing by the owner.

Contractor Performance Evaluation

To fully examine the quality of a contractor's performance, several subjective elements must be addressed. If the contractor has difficulty in performing on a contract, the internal control systems are subject to scrutiny. In considering the process, however, how does poor design influence the number of claims and changes, if these are measured criteria - particularly in construction, where the contractor is using designs created by others? What of carry-over bias from previous projects, or 'the contractor's reputation' influencing evaluation responses.

CONQUAS - Construction Quality Assessment System

The Construction Industry Development Board (CIDB) of Singapore developed this system of contractor assessment. It was developed as an objective quality measurement system for building construction. It has also been applied to civil construction. Its purpose is to provide an incentive scheme for encouraging contractors to improve the quality of their construction. The incentive process awards a contractor by allowing them up to a 5 percent premium on bidding or $5 million whichever is lower. Thus, a contractor with a high CONQUAS rating can bid higher than a non-rated contractor and still be awarded the contract.

The CONQUAS system has defined the criteria or tolerances for inspection and determines to what extent a project satisfies those requirements. Rather than performing a complete building inspection the system is based on obtaining a representative sampling of the building areas. The sample size is determined by the physical size of the structure. Figure 2.2 illustrates the three primary component areas of the scoring system. As described in the CONQUAS manual, the weight system is "a compromise between the cost proportions of the three components in the various buildings and their aesthetic value." (p. 5) The three basic component areas are structural, architectural, and mechanical – electrical (M&E) work. Project categories are described in Table 2.5. Figure 2.2 also provides the inspection point tolerances for one of three formwork elements. Figure 2.3 illustrates the scoring process starting at the inspection points. Basically a percent passing the inspection points is calculated, depending on the number of locations used for CONQUAS inspections. This value is combined with other elements in the same component. Formwork is one of seven elements in structural works. The structural total is weighted a second time based on the building category in Table 2.5. The sum of the three component scores is used as the final building score.

Table 2.5. CONQUAS Building Categories and Weight Scheme.

Components	CATEGORY A Offices, shopping malls, industrial buildings, airports, hospitals, etc.	CATEGORY B Condominiums, institutional buildings (schools etc)	CATEGORY C Public Housing	CATEGORY D Landed properties
Structural Works	30%	35%	45%	40%
Architectural Works	50%	55%	50%	55%
M&E Works	20%	10%	5%	5%
CONQUAS SCORE	100%	100%	100%	100%

Application of CONQUAS

The score is currently used in the bidding process as a premium for the contractor. The following rules apply:

- Average quality assessment score on past three projects must be above 65.
- A premium of 0.2 percent of the contract size is given for every point above 65.
- The maximum premium is 5 percent of the project bid total or $5 million, depending on which is lower.

This system of objective measurements allows the award of a contract to someone other than the lowest bidder when the bid is adjusted for the quality premium based on the CONQUAS score. An independent third party conducts the scoring process. One analysis suggests that tendering premiums may be most effective on large projects. An analysis of bids in the referenced material suggested that the difference between the two top bidders was generally

Inspection Results
Example:
10 formwork inspection areas would provide 110 points of inspection. Assuming 90 passed the tolerance criteria, a score of 90/110 or 0.82 would result.

Architectural Assessments

Structural Assessments

Structural Works	Weight %	Score
Formwork	**10**	**8.2**
Rebar	20	17.6
Finished Concrete	30	28
Concrete Quality	10	10
Reinforcement Quality	5	5
NDT Conc. Uniformity	15	11.5
NDT Conc. Cover	10	5
TOTAL	100	**85.3**

SCORING
The **formwork score** is weighted as 10% of the structural total. Thus, 0.82 X 10 = **8.2** points for formwork. Elements are summed for the component's score.

AREA	ACTUAL SCORE	CAT A Weights	Building Score
Structural Work	**85.3**	30%	25.6
Architectural Work	68.9	50%	34.5
M&E Work	85.7	20%	17.1
TOTAL			77.2

Figure 2.2 Three primary component areas of the CONQUAS system.

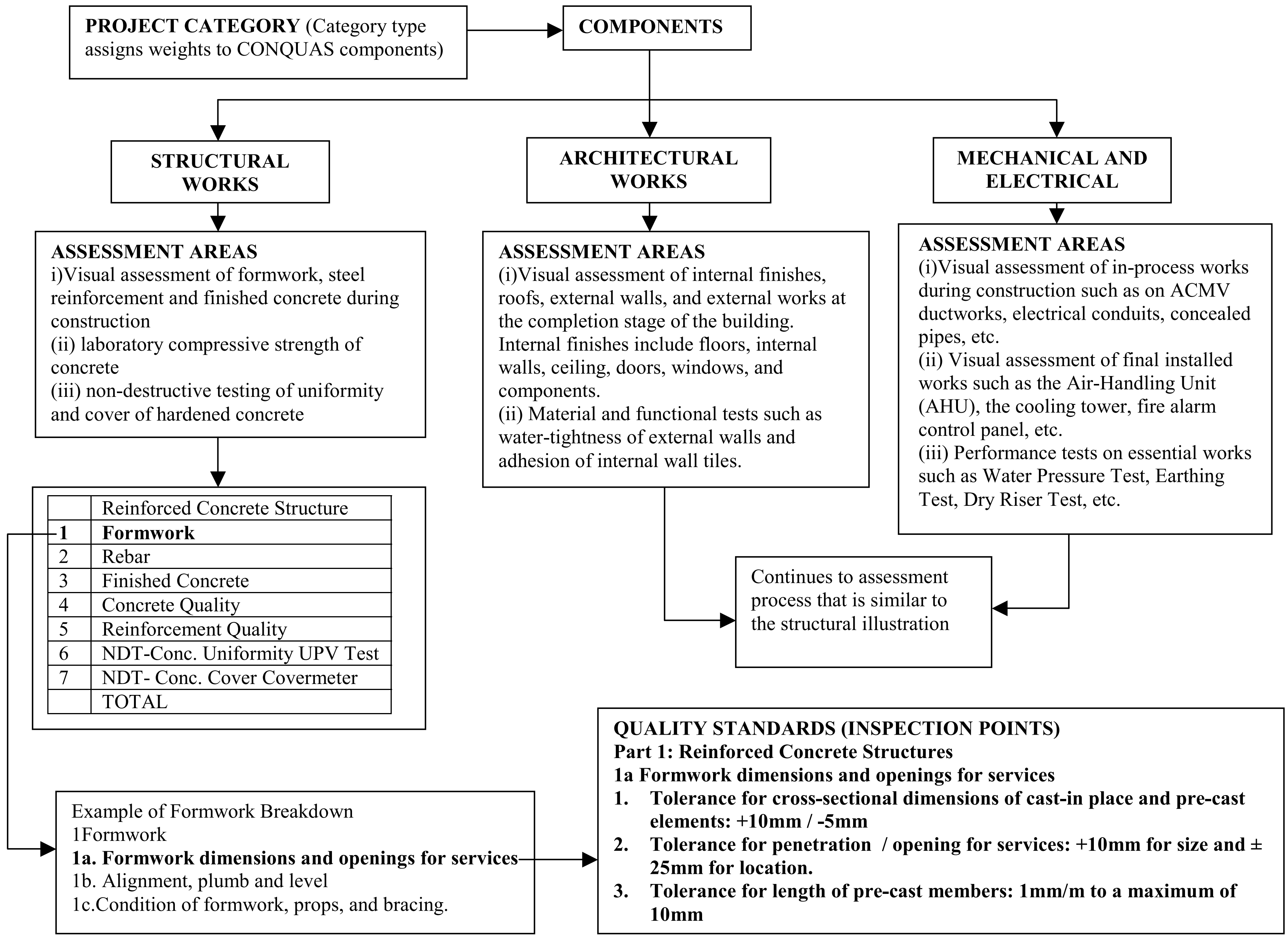

Figure 2.3 CONQUAS scoring process

smaller on larger projects. Contract size bias, from this perspective is an important element to consider if the QBPS is used in a similar fashion. (Prasertsintanah, 1996)

The CONQUAS model provides several clear advantages:

1. A well-defined measurement scheme that permits measurements among various projects to be compared on an equal basis.
2. The independent third party is not involved in the project and views quality and test results with out knowledge of interacting factors.
3. By modifying the bid amount rather than the prequalification, the contractor is being rewarded for consistently providing above the targeted level of quality. The target level of 65 would represent a project that meets the minimum acceptable level of quality.

Disadvantages of the CONQUAS approach are:

1. Does not consider the effectiveness of the contractor's safety or management systems.

2. The cost of supporting a third party process must be considered in weighting the total costs. The third party costs are in addition to the increased cost of performance for those situations where contracts would be awarded to someone other than the low bidder based on the premium calculation.

More of a concern than disadvantage is the use of cost as the basis of structuring the matrix of weights for the various buildings. However, this does permit distribution of quality items on a rationalized objective basis rather than a subjective basis.

OTHER INTERNATIONAL EFFORTS

Another avenue explored in the literature was qualification and past performance practices Europe and Asia. European practices in these areas tend to concentrate on quality management system certifications and similar practices. Responses from several individual government agency contacts suggest that quality performance is being actively considered, but no solutions have been proposed

The following is information taken from advertisements and bid documents for projects let by three Asian agencies as typical requirements for major civil works.

Korea. The Korea Airport Construction Authority contracted for the construction of the New Seoul International Airport. In 1995 the owner was searching for a foreign contractor to team with a national (Korean) contractor in a joint venture. Each of the companies completed forms and submitted required information. A Project Performance Plan was submitted along with other required documents. The documents were reviewed and rated based upon the "Construction Authority's self-imposed evaluation system." The entity with the highest rating was then selected, and negotiations began.

As is the custom in the Far East, Research and Development holds a high priority. Questions about a company's R&D Program would not be expected in the US, but are not uncommon in Asia. This is an important issue in the prequalification process.

They are also very interested in the key personnel in each bidding company. They request a Curriculum Vitae for each company's officers, a Work Program and Time Schedule for each of these key personnel, their assigned tasks, and their employment records.

Inchon International Airport. This 1997 project has the same requirements as the Seoul Airport including the joint venture with a Korean firm and a foreign firm. This time, however, the proposal procedure was different. Requests for Proposal (RFP) will be issued to the short-listed consortia. The consortia is comprised of those entities which successfully pre-qualified. The prequalification requirements are based upon licensing and documented work experience.

Hunan Changsha Power Plant is located in the Peoples Republic of China. This 1997 project sought a foreign company to perform a turn-key contract on the power plant. Open, international competitive bidding is the method of procurement. Interested companies were invited to apply for prequalification. Prequalification is based almost totally on experience. Evaluation criteria include submission of evidence on experience in design, construction, maintenance, operation, or financing of power plants.

MISCELLANEOUS

Hybert (1996) reviewed quality problems in companies that use a contracting process to provide customized, large-scale systems or products. This can be extended to quality problems on many construction projects. Hybert identified five primary quality-based problems:

1. Poor up-front definition of customer needs.
2. Incomplete evaluation criteria for awarding the contract (overemphasis on price).
3. Poor planning of project objectives.
4. Poor assimilation of necessary midstream project changes (driven by problems or improvements discovered during the project).
5. Measures and rewards driving the wrong performance.

Price remains the predominate criterion for awarding the contract in most jurisdictions. Hybert (1996) observed that specifications usually define only the technical aspects of the solution; the specifications do not commonly address quality requirements, customer satisfaction requirements, or cost considerations. Another comment related to construction was that, in retrospect, specifications (and drawings) are often inaccurate or incomplete. Looking back on projects, it is easy to see where errors were made that should have been prevented in the development of the design or match-up of specifications. Although not commonly done in construction, Hybert suggests the use of quality, function deployment (QFD) to define functionality, quality and cost requirements, and gain more alignment between these features and the specifications.

Hybert asserts that current bid practices may de-emphasize the importance of alignment between the contractor and customer so that both work toward the same end. Instead, these practices put the contractor and customer in an adversarial relationship, possibly putting one party in a position where it needs to take drastic measures to recover. Excessive change orders and claims might be reflective of this problem.

The concept of teaming or partnering (in a non-legal sense) stresses having fewer suppliers and working closely with them so they understand the customer's needs well. This way, both the customer and the supplier have a stake in each other's success. There are risks to both parties in a teaming approach, since it requires mutual trust. Teaming can reduce the need for costly risk management tactics (change orders, claims, using the specifications as a shield to avoid work requirements, etc.).

Too often, contractors are winning contracts by underbidding, exaggerating delivery capabilities, underestimating the project risks, or under-solving the technical problems, just to get a lower price than their competitors. They are also rewarded by change orders for their ability to argue specification interpretation issues. (It is notable that Hybert was discussing major telecommunications contracts - not construction contracts! The construction industry may feel that the problems are isolated to their domain, but articles from other industries indicate otherwise.)

CONSTRUCTIBILITY REVIEW

Many owners are requesting that contractors document their quality process along with their results. Quality assurance or quality control process documentation would be valuable in evaluating a contractor for the purpose of bidding eligibility. However, relying on a binder of materials or an external certification to validate quality contractors does not assure that the products delivered will be high quality. Owners should realize that just because a contractor has a quality assurance program and process does not mean that the contractor will deliver more than the specified minimum quality. While for some contractors this alone may be an improvement, this may result in a "dumbed-down" concept for quality. If the specifications represent the minimum acceptable quality, the contractors would be wise to devise systems and processes to deliver that level of quality with great assurance. Thus, before embarking on a mission to improve quality by prequalifying contractors for quality, a DOT must be sure their processes provide specifications and drawings commensurate with the quality of output desired. The DOT must assure that processes and personnel are compatible with the targeted quality level.

To that end, the Florida Department of Transportation has instituted a plan whereby each district has a Bidability/Constructibility Engineer. This engineer is generally one with a construction background (though not always). The engineer has a staff made up of experienced, full-time design and construction personnel who review every set of plans that will be let for bid by that district.

Previously designated DOT personnel had reviewed plans at several project development stages (30 percent design, 60 percent design, and 90 percent design). Additional department personnel occasionally checked projects at the 100 percent stage. This process is still in place. However, now, after this has been accomplished, at the time when the plans would have formerly gone to bid, this new Bidability/Constructibility staff reviews the plans. The number of mistakes caught by this staff after the former process is complete varies from job to job, but is sometimes so high that one of these Bidability/Constructibility Engineers could only classify the number as "scary." It would seem reasonable that after the traditional 30-60-90 percent reviews were completed, there would be only a rare error for this team to find, but this apparently has not been the case. Thus, design review or design performance is an important consideration in the institution of contractor quality performance measurement.

SUMMARY

The review of the literature revealed two distinct approaches to contractor performance measurements. The post-performance DOT surveys and the CONQUAS and QPMS measurement approaches were reviewed. In addition, other considerations were identified such as constructibility reviews, post-construction inspections and ISO certifications. Many of the advantages and disadvantages of each were identified.

The use of a certification process for quality management systems was not found in the current DOT literature review. However, its use as an element in evaluating contractor responsibility determinations should not be overlooked. It was not clear from the review of the literature that an ISO certification is based on contractor performance in the broadest sense of the term demonstrated by the DOT performance questionnaires.

Many of the DOTs use a post-project evaluation or contractor evaluation process to gather data on contractor quality. Therefore, including this type of measurement scheme would not have much resistance among those currently using surveys. The requirement for an ISO certification would have little impact to DOT operations, but would require time for contractors to develop. They would likely pass the cost of this requirement to the DOTs. Unlike the reduced prices realized by incentive schemes implemented by Minnesota, it is not clear if a similar result would occur from third party certifications.

While Missouri has developed a detailed questionnaire keyed to their specifications, other DOTs use very generic, almost open-ended, questionnaires. Interpretation keys can aid in response consistency. It was not clear in some cases how the information obtained from the survey was used in the determination of bidder responsibility. In others the ability factor was determined from the questionnaire. The current state-of-the-art could best be described as consistent in categories or subjects examined, but inconsistent in methods of measurement and application of information gained.

CHAPTER THREE

MODEL FACTORS

PURPOSE

This chapter will focus on reviewing a wide variety of factors that the literature, the researchers, and the focus groups indicated should be included in any model used to evaluate a contractor's performance and quality. Generally, the concepts of performance and quality were not clearly differentiated.

FROM THE LITERATURE

Table 3.1 is a consolidation of the various factors from the literature and qualification forms that were discussed in some fashion on qualification of a contractor or contributing to quality. Measurement schemes for some of the factors listed in Table 3.1 are not compatible for developing a cumulative or overall value for qualification. Some are purely numerical, expressed as a percent or dollar value, and others require a subjective response. The original concept of the QBPR was that a single factor for quality-based performance would be determined for rating or valuing the performance of the contractor. In addition, it would appear that the criteria of the factors listed are different in many ways and that a consistent set of criteria would be valuable. Some evaluate the contractor as a whole, while others evaluate project factors.

PROJECT EVALUATION CRITERIA

A conservative approach to contractor evaluation focuses on the contractor's specific projects rather than the contractor as a whole entity. Napier and Freiburg (1990) provided broad guidelines, which might be useful when developing the final set of criteria for evaluation of a project proposal. They assert that the following evaluation factors are of primary importance:

- Must reflect the most important features of the project.
- Must identify items sensitive and critical to the project that would distinguish a successful project from a failure.
- Must address the more general, fundamental aspects of the project rather than definitive details.
- Must address features of the project left open to the proposer's individual design solution.
- Must address features of proposals that can be reasonably judged for quality and for which values can be assigned.
- Must be consistent with the size and complexity of the project.
- Should not address items that are specified prescriptively in the RFP.
- Should not be included for items which when exceeding the minimum specified performance, will be of no advantage to the owner.
- Should not address items of such detail that conformance can be judged only by

examination of the final design or analyses and shop drawings or construction submittals.

- For the quality value rating:

  - A coarse scale of no more than five increments.
  - A point value scheme can be assigned to the different intervals for a quantitative analysis.
  - Evaluators must be able to clearly distinguish between any two categories to give meaningful assessments.
  - Ratings of poor and unacceptable are not necessary because proposals that do not meet minimum requirements should not be considered.
  - A numerical scheme is to be used as a point of discussion to clarify relative qualities and not used as the actual evaluation exercise

Table 3.1. Possible Quality-Based Performance Factors and Measurements.

CATEGORY	**FACTOR and DESCRIPTION**	**SUGGESTED MEASURMENT CRITERIA**	**COMMENTS**
PERSONNEL	Management directs quality work aimed at customer satisfaction	High level of direction to low level of direction	A qualitative factor measuring the commitment to quality work
	Integrity	Convictions of company officers for improper business practices	Any company officers convicted of wrongdoing with contracts? Disqualification factor only.
	Cooperation – promotes implementation of customer demands	Satisfaction or Binary Scale	Also a qualitative factor.
	Effectiveness	Satisfaction Or Binary Scale	Do project personnel waste time making decisions?
	Adequate Work force	Staffing appropriate to the project size and complexity	Project Staffing – All levels of staffing or just contractor management
	EEO Requirements		Satisfactory
	DBE Requirements	Binary Scale	Meets or exceeds requirements on contracts

Table 3.1. Possible Quality-Based Performance Factors and Measurements (continued).

PROJECT MANAGEMENT SKILLS			
Project Control	Quality Control Plan	Scored against requirements list for a QC Plan	Complies with requirements
	Safety Plan	Scored against requirements list for a Safety Plan	Does the contractor follow the plan?
	Safety management	Project-Based EMR-type factor or OSHA Incident Rate	Safety executed according to Safety Plan
	Required documents submitted on time and in proper form?	Percent of submissions made on time; percent of submissions returned as incomplete	Failure to submit certain documents can result in payment stoppage.
	Completes contracts	Failure to complete one or more contracts	Time period needed to ensure contractor can improve. Five-year past history possible measure limitation
Public Relations	Traffic Control -	Meets or exceeds requirements	Lane changes made on schedule
	Public Relations -	Number of contractor-caused complaints	Scaled value ranging from few to many to epidemic
Cooperation	Changes/disputes avoided by seeking solution	Percent of time contractor responded satisfactorily when approached for help	Quickly solving problems in a cooperative environment

Table 3.1. Possible Quality-Based Performance Factors and Measurements (continued).

CATEGORY	**FACTOR and DESCRIPTION**	**SUGGESTED MEASURMENT CRITERIA**	**COMMENTS**
FINANCIAL			
	Bank references	Positive evaluations of bank personnel	
	Line of Credit with vendors	Dollar value	
	Net Worth, Working Capital, Liquid Assets, Net Adjusted Worth, Surplus Net Worth	Dollar value	Common features of bidder capacity formulae. Variations in their use and content. Required evaluation of each factor independently
	Equipment value	Dollar value	
	Financial Ratios	Dollar value	
	Capability	Has successfully managed similar–sized projects based on dollar volume	Dollar volume neither reflects the work the contractor will actually perform, nor does it reflect the complexity of a project.
SCHEDULE ADHERENCE	Does the contractor stay on schedule?	Was the contractor ever 15% behind schedule? Was the contractor in default? Did the contractor pay liquidated damages?	Numerous quantifiable measurements for this
CONTRACTOR'S ORGANIZATION	Knowledgeable personnel	Formal education of lead personnel professional registration	A person in authority should be within 45 minutes of the job at all times.
	Contact person – Authority lines Clear	Contractor identifies person with authority for project	
EXPERIENCE	Does the contractor have the proper experience to do this work?	Prior history of projects with similar work content	

Table 3.1. Possible Quality-Based Performance Factors and Measurements (continued).

CATEGORY	FACTOR and DESCRIPTION	SUGGESTED MEASURMENT CRITERIA	COMMENTS
PLANT/ EQUIPMENT	Sufficient equipment to prosecute the work	How measured	
	Equipment maintained in working order	Number of breakdowns per day (incl. Plant breakdowns)	
QUALITY OF FINAL PRODUCT			
Final product measurements	What is being measured?	Percentage of units torn out and reconstructed (per total units)	Number of units accepted at reduced pay or with penalty per total number of units
Paving Project Characteristics	Density	Percent of all samples below acceptance levels	Many of these factors are already included in payment factor incentive/ disincentive schemes.
	Thickness	Percent below acceptance levels	
	Smoothness	Profilograph rolling – straightedge	
	Strength	Percent all samples below design acceptance levels	
	Alignment –	Does the project meet alignment tolerance?	
	Appearance –	Is the desired appearance achieved?	Perhaps a third party could be used here.
Rework	How many rework / punchlist items does the contractor need to correct	Estimated percent of total contract value.	Amount of substandard work that must be performed a second time
	Rework caused by poor plans and specifications	How measured	Amount of effort in rework caused by poor direction in plans and design information

Table 3.1. Possible Quality-Based Performance Factors and Measurements (continued).

CATEGORY	FACTOR and DESCRIPTION	SUGGESTED MEASURMENT CRITERIA	COMMENTS
Housekeeping	Does the contractor keep the project free from accumulating debris and trash?	Inspection survey report rating	The literature supports clean project sites as an indication of a well-managed contract.
	Final Site Clean-up	Final inspection survey report rating	
Vendor-Supplied Materials	Do the materials chosen by the contractor meet or exceed the desired requirements?		Qualified Products List needed
Contact with Vendor – provided vendor information in timely manner? Does vendor provide requested information in a timely manner?			
	Provided vendor with P.O. or contract in timely manner		
	Prompt payment concerns	Were there any complaints from subcontractors or suppliers?	Were any complaints substantiated?

Although established with a proposal evaluation scheme in mind these guidelines are valuable considerations to establishing the QBPR evaluation scheme. Re-formulating these concepts yields the following guidelines for the QBPR:

- Address features of the project that contribute to the overall project quality.
- Address fundamental features of the project.
- Should not include items that are of no benefit to the owner.
- Consistent with project size and complexity.
- Evaluators must be able to distinguish between any two categories for meaningful analysis.
- Point values can be assigned for meaningful assessments.

Additional considerations for factors to be included in the final models would include:

- Ease of obtaining data (mirroring existing data systems is important)
- Eliminating bias occurring because of project phase
- Influence of the particular design on the contractor's performance.

The first element in developing the model factors was to solicit information from DOT personnel and contracting personnel.

FOCUS GROUPS

Focus groups were organized in Florida, Pennsylvania, Utah, and Kentucky. The Kentucky focus group consisted of DOT personnel, and discussion concentrated on their experiences with qualifying contractors for a particular project; otherwise, the focus groups consisted of a mix of contractor personnel and DOT personnel.

The focus groups were first introduced to the project concept and research approach. Minutes or summaries of the focus group meetings are provided in Appendix B. Each meeting was conducted with the same agenda, although due to interest in various topics, time was distributed differently.

The focus group participants offered many valuable insights. Each state process was unique. For example, in one focus group, most of the contractors were initially opposed to multi-criteria bidding that included quality (A+C or A+B+C bidding, where C = Quality); however, they were later persuaded by the other contractors in the group to re-evaluate their position. The reasoning used by the contractors favoring quality was that this could alleviate the problem of bidding against unscrupulous contractors, who were described as those who bid low with the intention of using the claims process or Change Orders to make their profit. By the end of the meeting, no one opposed the pursuit of a method to use (A+B+C) or (A+C) bidding. The general discussion revealed many of the current quality issues and factors of concern among the participants.

Another observation dealt with how the participants felt about including, as a factor, the type of work that a project entails or the size of the project. One contractor, seeing this on the agenda, brought supporting documentation to the meeting which showed that he was rated poorly on one project and highly on another. On the project for which he was rated poorly, he was a subcontractor and he performed one day of work for $20,000. On a project lasting nearly two years and worth almost $20,000,000, as the prime contractor, he was rated highly. His complaint was that his rating with that state's DOT for the one-day project had the same impact as the two-year project. This generated a wide ranging discussion on several fronts, one concern being project size and another project duration.

The project size discussion focused mostly on the issues of quality qualification. One participant asked, "Do we want lower quality on smaller projects? Are our standards any different?" The group discussed this issue and came to a unanimous conclusion. Everyone agreed the answer was "no," including the one who had brought the documents. It may be preferable, however, to rate only prime contractors with this model or to maintain subcontractor and prime ratings separately, although this distinction was never made very clear during the discussion.

The group also discussed whether or not the type of work should be a factor. They decided that this issue should be left to the individual states to handle as they see fit. For instance, Pennsylvania contractors are prequalified based on type of work. It is up to each contractor to become prequalified in any area in which he wants to work. Penn-DOT maintains a list of all contractors prequalified to do work in every area, from sign erection to paving to grassing. In Florida, however, one is either prequalified as a prime contractor or one is not.

The states already have established procedures – or maybe even regulations or statutes – affecting how to handle this and should retain the prerogative to handle this as they see fit. Any model generated by the study should be versatile enough to be used both by states that break down their qualifications by work type and by those who do not.

Neither the contractors nor the DOT personnel indicated that states being able to exchange or share information was important. The expectation was that DOTs would be interested in reciprocity of information, but they said if they've got questions about an out-of-state contractor, they just pick up the phone and call a state that the contractor has worked in before. Of course, for reciprocity to work, the states must be measuring the same criteria.

Participants in all four focus groups asked for a follow-up meeting or a report on the project findings. This type of request, and others like it, was interpreted as an indication of the high level of interest found in contracting organizations and DOT agencies to improve the current process.

RESULTS OF THE SURVEY

A survey to determine the appropriate factor importance and weights was distributed to nearly 1000 people in the industry. For clarity, each survey included a glossary of terms used in the survey. Appendix B contains a copy of the survey, a copy of the glossary, and a final tabulation of the survey results. Approximately 600 surveys were sent to personnel in every state DOT. Over 400 surveys were distributed among contractors in the states participating in the focus groups. Contractors often work in more than one state. Two hundred fifty completed surveys were returned. Of these, ten were deemed unusable due to failure to answer the questions in a proper manner. Respondents were asked to rate eight factors, selected based on suggestions from the Focus Groups in order of importance to overall construction project quality. The factors were personnel, project management and control skills, financial considerations, scheduling, contractor organization, work experience, plant and equipment, and final product. Actually, these are major criteria that contain several factors within their definition. In addition to these factors, the respondents were asked to provide other factors they felt were important. The following list contains the major content of those responses from DOT personnel responses:

- Adherence to specifications.
- Partnering and cooperation.
- Contractor attitude.
- Communication.
- Quality of work, materials, quality plan, and initiatives.
- Safety.
- Public relations.
- Environmental concern.
- Technology.
- Subcontractors.
- Contract time compliance.

Contractor additional suggestions included:

- Claims (number and abuse).
- Quality (plans quality was questioned).
- Organization.
- Design quality.
- Extra work and rework.

Most of these factors were considered to be included in the 'glossary of terms' and not excluded from the evaluation. Several important topics from the additional suggestions were technology, subcontractors, and design quality; however, technology may be related to the requirements of the specifications. Minnesota's experiences that are related in Chapter 2 provide an example of specification influences on technology. Subcontractors in some states are currently prequalified and could be independently measured from a QBPR perspective; however, the DOT only has a direct influence and control on the prime. The design influence can be difficult in those states using consultant inspection forces. Some agencies currently measure consultant performance; however, this is outside the scope of the current research.

The results were tabulated for DOT personnel, contractors, and all respondents (see Table 3.2.). Since the overall distribution of the surveys heavily favored the DOTs, a comparison of the rankings was deemed appropriate. The team found it quite interesting that the contractors and DOT personnel generally had similar rankings. The greatest area of disparity was in the area of "Financial Considerations"—the contractors felt that this was the third most important consideration, whereas DOT personnel ranked this lowest. The combined ranking reflects the overwhelming weight of responses by DOT personnel in the survey. This ranking is consistent with the guidelines described earlier; i.e., that the eventual user will be the DOT, and the scales should reflect their interests. A surprise factor was the overall ranking of schedule adherence. It was consistently low between both surveyed groups. Contractors ranked plant and equipment last because they are capable, in most circumstances, of renting or leasing equipment needed for their work; however, the influence of equipment on quality is more likely reflected in the DOT ranking.

When both groups' responses were combined, there was a definite break point between the top four factors and the bottom four. The analysis of the responses is provided in Appendix B. There was much more interest in the top four factors than the bottom four, and the weights assigned to the model factors are a reflection on this variable level of importance. Additional factor discussion will be reserved for the model development phase. The objective of identifying the primary categories for model factors was achieved from combining the literature findings with the focus group and survey data

Table 3.2. Quality Factor Rankings.

FACTOR	DOT RANK	CONTRACTOR	COMBINED
Personnel	2	2	2
Project Management/Control Skills	1	1	1
Financial Considerations	8	3	8
Schedule Adherence	7	7	7
Contractor Organization	6	6	6
Experience with this type of work	4	4	4
Plant and Equipment	5	8	5
Final Product	3	5	3

Survey Questions

In addition to ranking the alternatives in the survey, four questions were asked. The first question was: *Is it possible to justly rate a contractor's quality of work and tie it to qualification?* When all of the respondents are considered, 80% said yes,12 % said no, and 8% gave some other answer. Of the DOT respondents, 83% said yes, 9% said no, and 8% gave some other answer. Of the contractors, 66% said yes, 28% said no, and 6% gave some other answer.

Table 3.3. Breakdown of Answers to Question 1:

"Is it possible to justly rate a contractor's quality of work and tie it to qualification?"

Respondents	Yes	No	Other
Owners	139	15	13
Contractors	23	10	2
Total	162	25	15

Nearly a third of the contractors did not think that this would be feasible. The second question was: *Is it possible to justly rate a contractor's quality of work and factor it into a bid to determine the awardee of a contract?* When all respondents are considered, 47% said yes, 37% said no, and 16% gave some other answer. Of the DOT respondents, 50% said yes, 33% said no, and 17% gave some other answer. Of the contractors, 34% said yes, 57% said no, and 9% gave some other answer.

Table 3.4. Answers to Question 2:
"Is it possible to justly rate a contractor's quality of work and factor it into a bid to determine the awardee of a contract?"

Respondents	Yes	No	Other
Owners	83	55	29
Contractors	12	20	3
Total	95	75	32

The third question was really more of a request: *"Please suggest a method which you feel would provide the most objective system for a DOT to rate a contractor based on quality of work."* Some of the thought-provoking responses were:

- "Send a questionnaire to each supervisor with the DOT that has a project with this contractor and have him or her rate this contractor's quality of work (against) what the supervisor expects of all contractors."
- "Have all final inspections conducted by an agency or branch other than the one who inspects/administers the contracts."
- "The DOT would rate each contractor on each project that he does, and this could be quantified historically."
- "Use five projects, but throw out the worst."
- "Form a review team—three people, one from DOT, one from industry, and one from non-related business."

The fourth question was simply a request for additional comments. Some of the more interesting responses were:

- "…using a rating system to modify and award bids would be entirely too subjective and would result in many projects ending up in court."
- "There should be some kind of qualification system for subcontractors bidding DOT work."
- "…it would be helpful to require some certification(s) to help assure that personnel have adequate training (not simply experience) in areas directly applicable to the work being performed."
- "I have had projects where the contractor has had a bad reputation, but by the contractor's placing an adept superintendent on the job, and through informal partnering, has performed well."
- "This is a must for quality projects. Authority must be granted for enforcement."

Of course, to make the factors in a model usable, there must be questions for the reviewer to ask. These questions should be quantifiable where possible, or set up in such a way as to be as objective as possible. One way to accomplish this is by asking only yes-no questions in sufficient quantity so as to gain an accurate depiction of the project quality. Yes-no questions are least prone to bias if asked properly, but in many circumstances, they may need some clarification.

To that end, over 100 questions were collected for evaluation. These are available for review in Appendix C. The questions were extracted from performance surveys provided by DOTs, literature commentary, and the researcher's contributions. They have been sorted by each of the eight factors. There are duplications, leading questions, and some that may be poorly worded. The intended purpose of the listing was to organize the questions according to the factor areas. They were reconsidered in the model development phase presented in Chapter 4.

A comment to the final product questions should be made at this stage. Many final product evaluations are conducted according to the project specifications. Model development in Chapter 4 will exploit these factors in greater detail.

SUMMARY

Several important findings were identified from the exercise in which factors were rated, survey evaluations were tabulated, and focus group findings were recognized. Assuming that the DOT and contractors agree on the broad or general subject criteria to be used in the model:

- Some resistance by contractors can be expected. Less than half felt it was possible to rate a contractor and factor it into a bid.
- Contract size, although resolved as an issue in one focus group, should be included in the model development stage.
- Reciprocity was not a major concern, nor did it seem that the groups were interested in direct reciprocity.
- Two groups of criteria were identified in the survey response analysis.

These factors identified in the chapter were used in the development of the model described in Chapter Four.

CHAPTER FOUR

MODEL DEFINITION

The general scope of quality-based qualification does not immediately lend itself to selection of a single model. The initial process suggests development of at least several alternative models. Figure 4.1 presents a highly conceptualized model of the traditional Design-Bid-Build environment, including the measurements of quality identified in the process. The model also suggests where each contracting party exerts the most control.

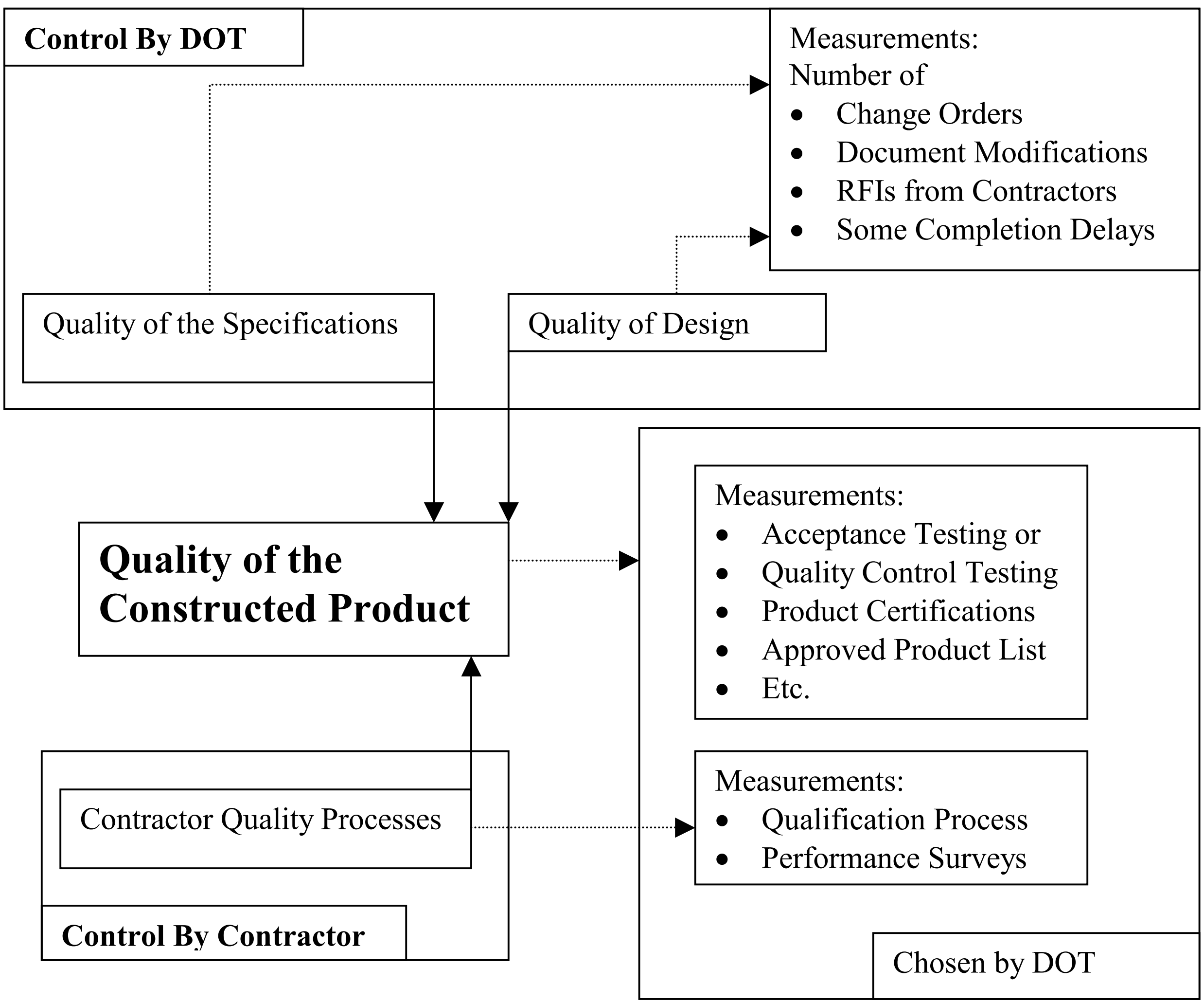

Figure 4.1. Traditional Project Quality Determinants.

A contractor's output quality is partially determined by the specifications and design. The potential for error is greater where contractors are working with defective designs; too much reliance on specifications to handle all quality aspects is also problematic. Some assurance needs to be built into the measurement process to separate or effectively eliminate the influence of such elements if measurement of a contractor's process and output quality is to be accurate. Even without such assurance, the contractor's performance can be measured if pre-existing quality deterrents are accounted for in the analysis. For example, the percent of rework caused by faulty design, design changes, or inappropriate specifications could be used to discount any penalty assessed due to contractor performance, or the contractor and DOT could prepare a report card on the designer's qualifications. The development or inclusion of a design evaluation process is outside the scope of this research; however, some DOTs and one contractor organization in Canada have considered the use of designer performance evaluations.

In the past, the DOT's primary role was to inspect all of the contractor's operations with great frequency. Over time, many inspections have been replaced with certifications of various types, or a manufactured product can be placed on an approved product list. For the most part, on-site inspection activities remain in the areas of natural site materials and pavement materials; therefore, the materials incorporated into the final product have been either site-inspected, plant-inspected, or accepted on the basis of a manufacturer's certification. In predominately method-specification projects, the DOT is required to perform a significant amount of testing, on and off the project site. The DOT's laboratory must be staffed to accommodate a rather large number of samples for storage and disposal. The move toward performance specifications that require contractors to perform quality control does not eliminate the need for inspection and testing; it simply shifts more of the initial testing to the contractor. The DOT still performs assurance testing to support or verify the contractor-reported test results.

If the proposed QBPR system were to include all of the processes and not simply the final product acceptance, then the quality performance would require that the design and specification influences on the contractor's ability to perform the work should be carefully examined. In addition, most contractor performance reports are prepared and submitted by the DOT site representative. The potential for bias to exist in final questionnaire evaluation was described in Chapter 2; therefore, the method of qualifying or evaluating contractor quality performance should be evaluated from a wide variety of perspectives.

CONCEPTUAL MODEL ALTERNATIVES

The conceptual approaches to selecting models were based on the following alternative considerations that group the common techniques identified in the literature into two alternatives with two model concepts in each group. The alternatives are:

Alternative A – Third-party Assurances

Third-party processes as currently understood could include the following choices:

1. Require the use of ISO 9000 as a possible method of achieving the desired goal.

2. Develop a third party audit process similar to the CONQUAS approach described in the literature review.

Alternative B – Questionnaire Models

Develop models from available project data using a format similar to the current method employed by most DOTs, plus objective quality measurements similar to CONQUAS.

1. Develop a factor model based on a questionnaire approach similar to that used by various DOTs for evaluating contractor performance.
2. Develop a factor model that includes or is constructed from objective quality measures. Those measures would include a combination of construction process questions and evaluation of the final products.

To evaluate each model approach, the eight key factors from the literature will be considered, with implementation considerations for each model.

USING ALTERNATIVE A – THIRD-PARTY PROCESS MODELS

ISO 9000 Alternative

ISO certification is an independent audit process based on a third-party review of a contractor's quality systems. ISO was described in some detail in Chapter Two, including advantages and disadvantages. The material will not be repeated here. A key contractor concern for the ISO system will be implementation cost. The cost of certification from earlier reports is conservatively reported to be in the neighborhood of $200,000. Assuming this to be an accurate cost, the initial cost for implementing ISO 9000 as a mandatory requirement for bidding or qualification purposes would be a large burden on the industry. ISO looks at each production facility, so contractors with regional offices in several states might need to certify each operation. Ultimately, the cost of this program would likely be passed on to the DOT.

The impact of ISO 9000 implementation on competition levels might be considerable. Smaller contractors and those that perform a limited number of DOT contracts might elect not to participate if qualifications for bidding are increased in this manner. In addition, given that DOTs currently perform many of the functions of material and supplier qualification, the added value of ISO 9000 as a qualification tool is somewhat diminished; however, this also could be an opportunity to eliminate DOT certification processes and qualified products lists, since the ISO registration process would consider many of the same criteria, and the burden of demonstrating those qualifications would rest with the contractors. Therefore, from a DOT perspective, the use of ISO may have some explicit benefits, but the level of competition might be reduced due to cost of attaining ISO registration. The ISO model evaluation is presented in Table 4.1.

Table 4.1. ISO Model Potential Evaluation.

FACTOR	MEASURED BY ISO 9000	COMMENT
Project Management and Control Skills	Not directly on projects. Overall company systems yes.	Would assure that proper systems were in place.
Personnel	Yes	
Final Product	Not directly	Requires inspection and testing with a feedback performance.
Experience with work	No	Implied with quality certification
Plant and equipment	Not directly	Implied
Organization	Yes	Key focus area
Financial Considerations	No	
Ease of Implementation	DOT see note 1 below. Contractor – significant impact	Contractors do not maintain their records in the manner prescribed.
Ability to use In All DOTs	Yes	
Useful for ranking or capacity ratings	No	Certification is yes or no.
Can evaluate on project basis	No	Certification reviews are 1-3 years with intermediate audits.
Legal Problems	Possible. See note 2.	
Cost	Unknown. Estimated high.	

Notes:

1. Typically contractors have been required to become ISO registered to bring their quality systems in line with owner quality systems. It is very likely that some incompatibility problems with quality systems could occur.
2. Might require legislative action to mandate a management system certification (like a license). High resistance to mandated systems expected from all contracting associations. Smaller firms do not have resources to maintain ISO. If a size exception is made, then a dual system would be required

The effectiveness of ISO 9000 has come under severe scrutiny in some quarters and has been found lacking in delivering promises of improved product quality; however, these studies are not conclusive at this time. To evaluate the ISO method in this application, the factors from the background evaluations and implementation goals should be considered.

An Alternative Third-Party System

Using a plan based on the CONQUAS system, random project sections would be selected and completely field audited. In keeping with the CONQUAS concept, the audits would need to be conducted by a third party to ensure that an independent evaluation has been provided. The resulting evaluation would provide a project score to be included in a quality score for the contractor.

Hypothetical Model

To prepare a model of the process, Table 4.2 is used to illustrate the preliminary concept, assuming a paving project for illustration. Separate measurement schemes would be needed for maintenance and structures work. A random sample of defined project sections could be selected and reviewed according to all elements of the contract requirements from the drawings and specifications. Contractors will argue that their subcontractors should not be measured with their work; however, the contract assumes the prime contractor has final responsibility for the finished product to the owner. Therefore, contractors will need to begin selecting or have an assurance process for obtaining the best subcontractors if the subcontractor scores are damaging to the project total. Likewise, if subcontractors desire work, then they also need to focus on providing high quality products to the prime contractor.

Hypothetical Procedures

1. Select 10 (or an appropriate number) random station increments during each project work phase. (Where appropriate) Subgrade Preparation, Base Preparation Final Pavement.
2. Measure/Evaluate all attributes in those 10 Sections Against Plans/Specification Requirements.

   FOR EXAMPLE:

   - Subgrade Density First Time Passing (Lab tests or new tests).
   - Base Depth (Sieve Analysis Results from random samples).
   - Point score based on specs.
   - Concrete Strength/Core Densities.
   - Air Content/AC Content or VMA.
   - Smoothness.
   - Drainage (Erosion areas, proper environmental protection).
   - Slope Configuration (X-section configuration).
   - Signage (not always applicable).
   - Pavement Markings (type, spacing, sample tests?).

3. Average the scores of all 10 sections together for each measured attribute.
4. Convert measurements to point score system relative to the work distribution. The scope of work in the contract would determine weights according to a pre-defined list of values.

Advantages:

- This approach removes nearly all subjectivity from the measurement.
- Only quality related attributes are measured and retained in the model.
- The process would be easily repeated on projects.
- Disputes are not likely on test results, unless testing is widely variant from project results.

Disadvantages:

- For complete independence, a new quality measurements industry would need to be created outside the existing heavy and highway community. Many of the existing quality management consultants in ISO would likely be involved.
- Ignores the desired holistic elements of quality that include contractor safety, schedule, project organization, and cooperation with the public, as well as the owner.

This audit process is reviewed in Table 4.2 for the model criteria evaluation.

Third Party Alternatives Summary

Neither of the third party evaluations is a perfect match to the attributes listed. The ISO model, however, has some attractive features for DOTs; that is, primarily, they would not need to administer the system, and it would address, on a broad scale, the contractor's ability to provide quality products. The CONQUAS-like system, which would involve a third party evaluation of the products in place, does not address many of the management issues that were thought to be critical to successfully measuring or evaluating a 'quality contractor.' The appeal of this type of evaluation is that the certification that quality construction and materials have been properly installed would be judged by an independent agency or consultancy.

USING ALTERNATIVE B – QUESTIONNAIRE-BASED MODELS

The next two alternatives primarily involve the use of a questionnaire to determine the ranking of the contractor, and, as such, they reflect a great deal of the current practices found in DOTs. The likelihood of implementation in either case is much greater due to the familiarity that DOT personnel have for this type of evaluation. They would likely have the most acceptance in states where prequalification is currently used, although with the exception of a few factors, they could be applied to nearly any jurisdiction wishing to measure contractor quality-based performance on a contract.

Table 4.3 considers Alternate B1, a subjective questionnaire similar to those currently used by DOTs. While many variations exist, there is consistency in the desired outcome. Table 4.4 considers a questionnaire model that includes data on the actual testing performed on the project and questions formulated in a more quantitative manner.

Advantages of the Questionnaire Model

- It can be more objective than most of the systems currently used by the states.
- It is similar to many current state systems in concept; therefore, the transition to this system would be simple for those states.
- It is relatively simple in principle.
- It rates a wide range of contractor activities.
- The product of the system is a number that can be used for many purposes.

•

Table 4.2. CONQUAS-Type System Evaluation.

FACTOR	CONQUAS TYPE SYSTEM	COMMENT
Project Management and Control Skills	Not directly	Project product focus only
Personnel	No	
Final Product	YES	Purely a final product focus
Experience with work	No	
Plant and equipment	Not directly	Only to the effect they have on final measurement
Organization	No	
Financial Considerations	No	
Ease of Implementation	Intermediate to Difficult	Requires complete definition of the system and components
Ability to use In All DOTs	Yes	
Useful for ranking or capacity ratings	Yes	Numerical quality ranking is the focus
Can evaluate on project basis	Yes	Pure project focus
Legal Problems	Low likelihood	All data measurable and can be replicated if challenged
Cost	Intermediate to High	Third party neutral evaluation would generate a new industry associated with DOT projects. Not a desirable outcome.

<u>Disadvantages of Questionnaires</u>

- It is similar to many current state systems. The states, by and large, are not satisfied with their current systems, often due to subjectivity of the data.
- It is deficient in the measurement of actual (final) product quality.
- Model weighting is commonly based on trial and error. This is significant because the weights of the factors have a great impact on the final evaluation.

Table 4.3. Project Performance Questionnaires.

FACTOR	QUESTIONNAIRES ONLY	COMMENT
Project Management and Control Skills	Yes	Can evaluate submittal accuracy and schedule adherence
Personnel	Yes	
Final Product	No – Only in a subjective way	Only in a subjective manner; no specific data are used.
Experience with work	Yes	In prequalification questionnaires
Plant and equipment	Yes	Also a subjective evaluation by the rating agency as to the adequacy of equipment
Project Organization	Yes	
Financial Considerations	No	In prequalification questionnaires
Ease of Implementation	Easy. Many DOTs currently apply post project performance surveys	Current process open to bias and single evaluator perceptions.
Ability to use In All DOTs	Yes	
Useful for ranking or capacity ratings	Yes or highly likely	Provided a proper weight and allocation of questions can be decided.
Can evaluate on project basis	Yes, applicable to any size and type of contract	
Legal Problems	Any contractor disbarred will likely challenge the evaluation system.	Requires careful consideration of checks and balances.
Cost	Low to Intermediate	Depends on the amount of construction. Consider integration with current AASHTO programs.

MODEL SELECTION CONSIDERATIONS

Based on the considerations of the two alternative approaches, the following observations are provided:

- An ISO system would likely be beneficial to the construction community, but the number of intangibles and unknowns suggests an extensive pilot effort would need to be conducted to determine the impact on competition levels. The pilot effort should concentrate on enlisting a DOT and contractors to experiment with ISO 9000 beyond a single project requirement. The researchers, initially informed that the ISO on the Utah I-15 project was abandoned, later were told the project joint venture had achieved ISO registration. The current evaluation from those contacted is that ISO registration has had no measurable effect on construction quality.

- The third party project quality audit approach has appeal from a pure product concept but fails to measure critical elements of management. If an independent third party is considered for this process, then the cost may quickly outweigh the benefit. Further examination of a scaled-back, less-expensive version might provide the product benefit.
- The questionnaire methods generally have some difficulty in the final product evaluation, where they are purely questionnaires.
- The alternative using the project testing information has the advantages of both the audit concepts in the CONQUAS-type model along with the ability to gather more or less subjective data on the contractor's field management performance and the quality of that operation. This alternative, among those evaluated, would seem to be the most logical approach to initiate the concept of measuring contractor quality on DOT projects.

CONCEPTUAL MODEL ELEMENTS

The following elements are proposed for the model development: project performance report, company performance report, and implementation applications. These three combined represent full application of the QBPR system. The first two elements are the model process.

1. The project field supervisor would conduct periodic project performance evaluations, which could be made at project milestones throughout the project. Periodic evaluations eliminate the possibility of bias–regarding the contractor (regardless of product quality) appearing in the final evaluation. The final project report would represent the cumulative findings on the project. Weights could be assigned to the interim and final project evaluations.
2. Project performance reports need to be combined either on a continuous basis or an end-of- year basis to assign the overall contractor evaluation. Project evaluations can be combined based on the raw scores or weighted. Initial weight considerations could be based on project size.
3. The performance report will represent the final evaluation of the contractor, based on the criteria. Qualification considerations must be given to the time period covered or the number of projects included in the evaluation. A procedure for admitting new contractors to the bidding process will also need to be established. Some prequalification states automatically reduce available capacity to one-half for new contractors. States that do not use a prequalification system will be able to use the system in Pass-Fail mode for determining whether the contractor is responsible in the performance of the work.

Table 4.4 displays an the results of an examination of the conceptual model, referred to as a mixed-data model because it incorporates both the conventional questionnaire and the unconventional but totally objective results of the testing of materials and workmanship.

Table 4.4. Mixed Data Model.

FACTOR	Mixed Data Model	COMMENTS
Project Management and Control Skills	Yes	Questionnaire
Personnel	Yes	Questionnaire
Final Product	Yes	Field Test Results Obtained by Contractor or DOT
Experience with work	Yes	In prequalification questionnaires
Plant and equipment	Yes	Subjective evaluation – Final product may be a better reflection
Project Organization	Yes	Questionnaire
Financial Considerations	No	In prequalification questionnaires
Ease of Implementation	Easy – Moderate	All data should be available unless new test methods specified
Ability to use In All DOTs	Yes	With exception of prequalification data, remaining data should be project based and available.
Useful for ranking or capacity ratings	Yes	Combining both subjective responses and quantitative data may be difficult.
Can evaluate on project basis	Yes	Frequency of measurement can also be varied for work phase considerations.
Legal Problems	Few – unless contractor completely disqualified	Challenges cannot be completely avoided in cases where contractor's ability to bid or perform work will be questioned.
Cost	Low-Intermediate	Depends on amount of construction. Consider integration with current AASHTO programs.

MODEL DEVELOPMENT

The previous sections discussed two very distinct approaches to quantifying the contractor's performance on a project. The models each measure important characteristics of quality performance by the contractor. It is also important that the method chosen be complimentary to DOT processes and not represent a process that is unreasonable in terms of implementation. The advantages of each of the models previously proposed are drawn upon and included in the following integrated approach. A good starting point would be to consider the traditional DOT contracting process. The major elements of a traditional contractor qualification process are shown in Fig. 4.2, which addresses both prequalification processes and non-prequalification processes. Non-prequalification states generally evaluate contractors after receipt of bids. The few states that do nothing except require contract bonds would not be concerned about either procedure and may elect not to evaluate contractor performance quality. The typical uses of prequalification data are for establishing a contractor's work classifications.

The contract items often have specified documentation submittals necessary to satisfy the quality management and assurance process. When considered as a whole, the documents in a project form a quality audit trail for major work elements. For example, if a specific item like concrete pavement were chosen for examination, then the master diary entries would provide information on when specific sections were paved and the related quantity book calculations. In addition, specific references would be made to field inspector diary entries related to the field inspections of that paving section and would include records on specific tests and the samples taken. Test result reports would then provide results of tests performed on the samples. The inspector diaries might also provide data on the depth of cover and field test results for air content, slump and visual inspection information. Unless the test reports fail a section or the contractor is unable to achieve required smoothness, acceptance decisions are made at this time. Smoothness and other post-construction quality measures are also performed for acceptance and payment formula requirements.

Once the contractor has had a determination on the payment issues, the project can normally proceed to the contract close out process that includes punchlist items recording incomplete work or unacceptable work remaining to be re-worked. Once the punch list process and final acceptance certificates are signed, the final payment can be made and the project moves into the traditional warranty or perhaps an extended warranty phase; however, little information is used as feedback into the contractor qualification from warranty.

Expanded Traditional Process

Figure 4.3 adds a post-project evaluation procedure into the picture. Some agencies use a post-project questionnaire model or rating for evaluating the contractor's project management and overall satisfaction of the contract requirements regarding safety, schedule, and other factors. The use of the information is highly variable among the various agencies, and the format of the questions is different for each agency. The feedback from these surveys may or may not be used to adjust the contractor's bid capacity or eligibility to bid future work. In most situations, unless the contractor has experienced significant problems in completing the project, the post-project survey may not impact the contractor's bid capacity or prequalification standing. The level of sophistication in the questionnaires and the ability to provide feedback to the contractor varies. A major drawback to post-project questionnaires alone is that they are most likely to capture the engineer's memory of the contractor's performance in the later stages of the project. Often, this is when some change issues or time extensions are being disputed. The potential for this form of bias is reduced in some agencies by using both field and district office evaluations of the project. The advantage is that someone not involved in the day-to-day project pressures may not be as biased toward the contractor, and other issues may be more evident at the district level than at the project level.

The following characteristics of the traditional system are identified as advantages or disadvantages:

Advantages

- Familiarity – the process, procedures, and working relationships are already established and comfortable for everyone.
- A distinct advantage for the reviewing agency is that most data used in contractor evaluation is collected and submitted by the contractor. This large volume of data needs to be evaluated and rated.
- Agencies using a feedback mechanism have some measure of contractor performance at least subjectively, and, where needed, payment reduction factors are used within the contract if test data performance is not fully satisfactory.

Disadvantages

- Potential for biased feedback on mainly subjective post-project evaluations is large due largely to the timing of the questionnaire. The contractor has no ability to respond or improve during the project.
- To be effective, performance feedback must have an impact on ratings. The inclusion of feedback performance data is not uniform.
- Construction and materials acceptance process is essentially independent of qualification procedures. Incentives or disincentive payments for construction and materials quality are generally limited to paving materials. Other types of projects may not have incentive possibility.
- Where bid capacity can be affected, the system may be slow to respond. Evaluations are often one year apart in prequalification.
- The current processes are punishment-based (reduced payments or reduced bidding capacity) and do little to encourage improvement beyond the minimum.

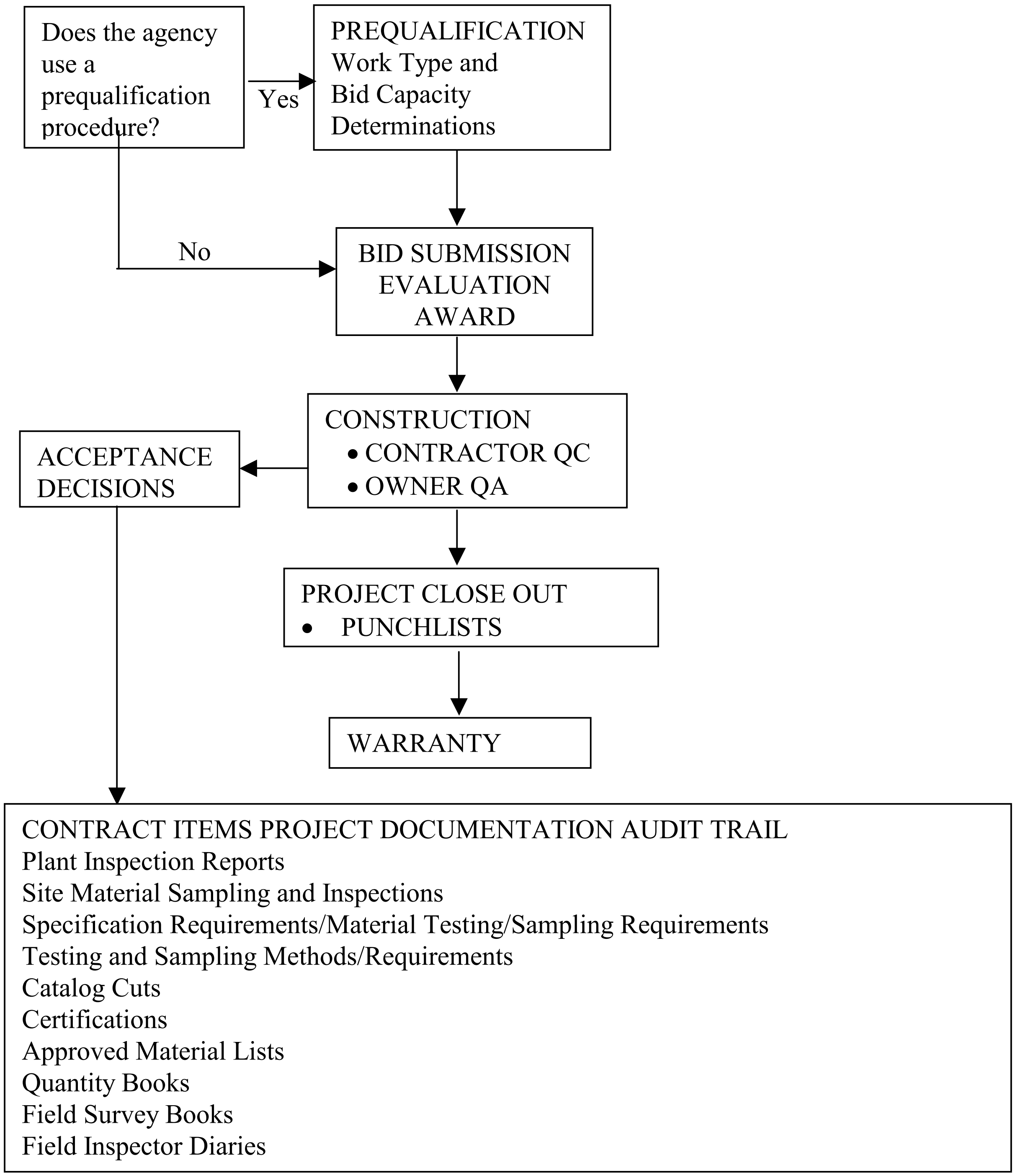

Figure 4.2. Traditional Process.

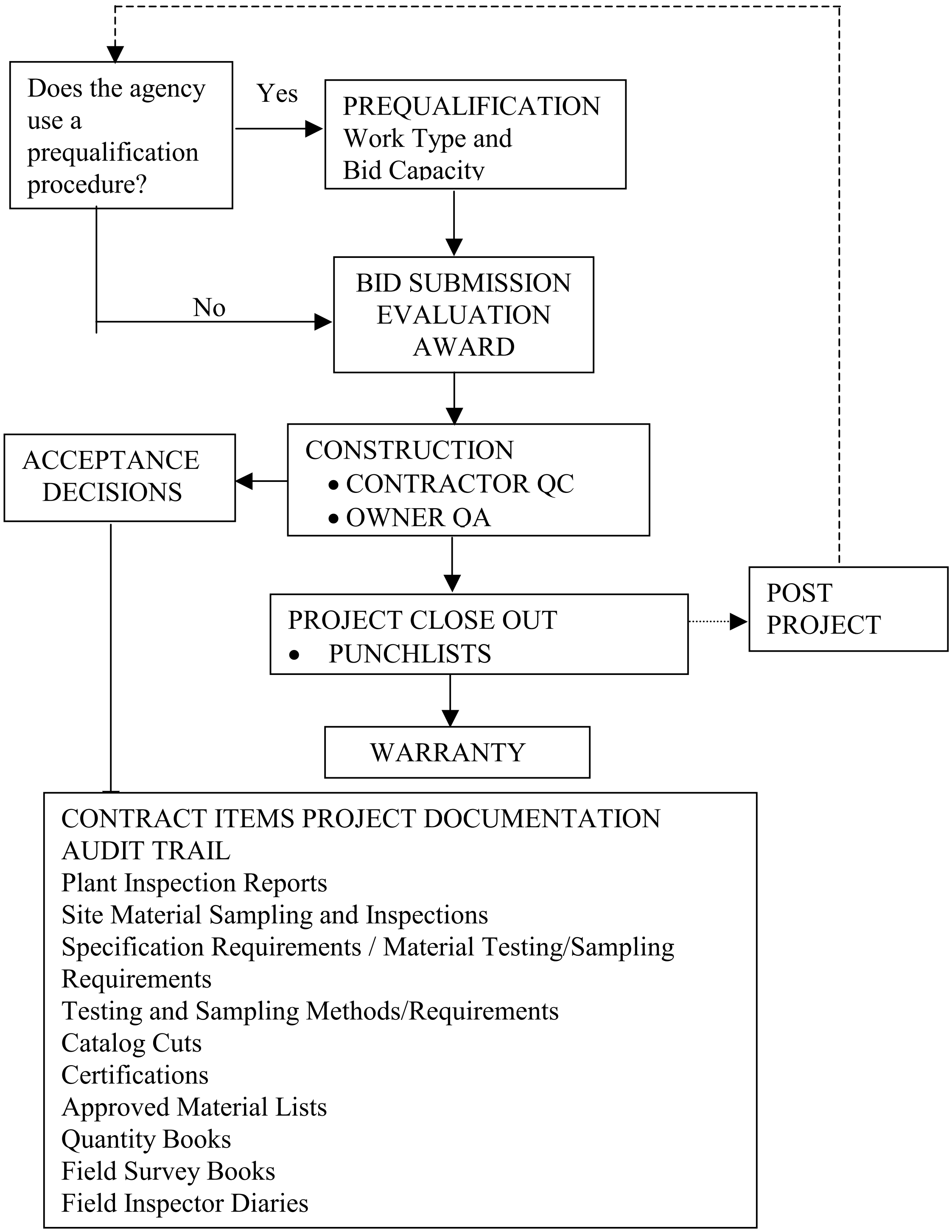

Figure 4.3. Model with Post-Project Evaluation.

Extended Qualification Process

Figure 4.4 demonstrates how the existing system can be modified to capture a combination of objective project performance data from the project test results and objective responses to the post project questionnaire evaluations. The proposed system reduces the potential for bias by tracking contractor performance during the construction rather than simply relying on a post-project evaluation. This is combined in a project performance report process with objective quality data collected from the project records. Various project performance reports can be used to generate an overall factor for the contractor for either the project qualification system or within the bid evaluation phase. Further details on the progress evaluation and the quality data schemes are discussed below.

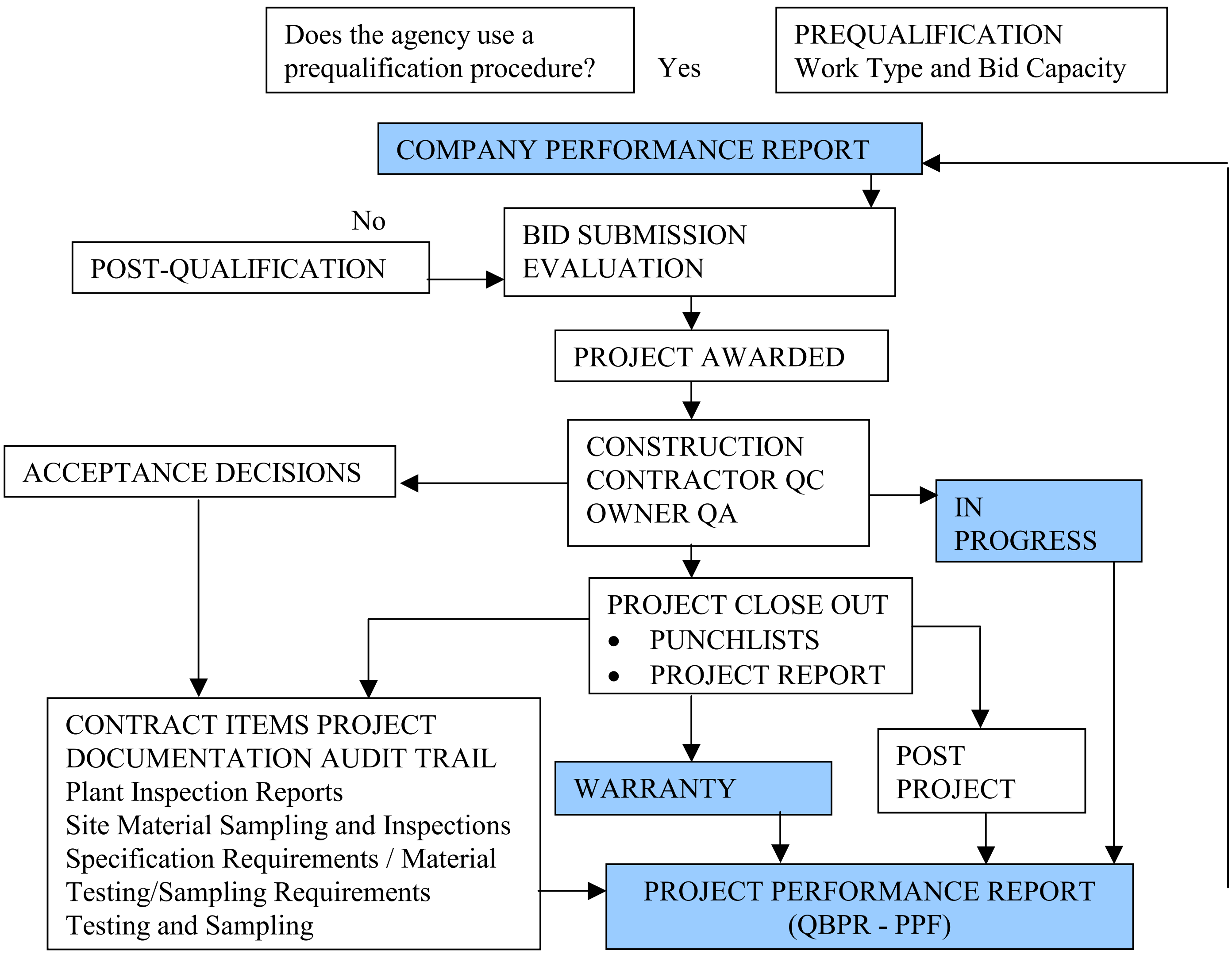

Figure 4.4. Model Combining Objective Rating Criteria with Questionnaire.

Tests to be counted in the final model will be initially based on the Group I and Group II recommendations for key construction inspection elements from the 1979 Federal Highway Administration Technical Advisory T5080.1.

An important element to evaluate in the model-testing phase is how many of these variables are needed for the intended purpose of trying to evaluate contractor quality performance.

Project Performance Factor (From a Questionnaire)

Financial considerations are not related to contractor performance on the project. It could be argued from an opposing view, but many qualification systems are heavily attached to determining a capacity factor. They need to collect basic financial information to determine capacity. Financial data may include work and activities beyond the DOT's concern. Furthermore, bonding requirements make the financial information more or less redundant if the requirement is a 100 percent performance and payment bond. There is no known tested or empirical data that suggest contractors fail from financial problems at rates any different in non-prequalification states as in prequalification states. Financial information may remain part of the qualification process, but it is not considered necessary or appropriate in a project quality performance model.

The contractor's preplanning efforts and knowledge of the project will be reflected in execution of the project and ability to maintain schedule progress. A project management and project control element will address the contractor's ability to coordinate and execute the schedule.

The contractor's organization reflects project personnel's ability to properly staff the project with qualified personnel. It is unlikely that upper management will have much influence on the project unless they delay payments to subcontractors or commit other poor business management decisions.

Experience with the work can be determined from qualification data and is not likely to change because of any particular project. This is clearly historical data, and the model is meant to measure current project data. If a DOT wishes to maintain experience requirements, then they may do so in addition to the model. This factor should be eliminated from the questionnaire model.

Plant and equipment will impact final product quality and the execution of the project. Poor equipment will impact the contractor's ability to maintain their schedule and will be apparent in the project control scheme. Alternatively, the contractor may have excellent equipment, but poor operators. The factor does reflect indirectly on quality.

Final product can be measured and often is measured directly. DOT personnel can collect data and evaluate the quality on the project, reducing the major criticism of the third party involvement (cost). If the final product will be measured, there is no need to include questions about the final products; thus, four factors remain in the Project Performance Factor Questionnaire (PPFq).

$$PPFq = a\,(Project\ Personnel) + b\,(Project\ Management/Control) + c\,(Schedule\ \ Adherence) + d\,(Contractor\ Organization) + e\,(Plant\ and\ Equipment). \quad (4\text{-}1)$$

Note: a, b, c, d and e are weight factors to be determined.

To overcome potential bias in the survey data, the project should be evaluated at intervals appropriate to the project completion. It would be very desirable to have one set of measurements conducted early in the project to identify problems associated with mobilization and start-up. Several mid-point measures would be recommended during key production periods and a review conducted at the end, much like the post-project performance evaluations conducted previously. Significant variations in the responses will provide a view of the contractor's performance. This is important because management changes, contractor, and DOT impact performance as much as other quality efforts. The periodic evaluations are viewed as key to obtaining less 'end of project' bias and a clear trend on project management quality.

The questionnaire is actually three questionnaires. One is to be an interim questionnaire, to be filled out by the Project/Resident Engineer at regular intervals throughout the life of the project. The second is a questionnaire to be filled out by the project/resident engineer after final acceptance of the work or after the final estimate has been paid. The third questionnaire is very short and is to be filled out by district or central office personnel after acceptance of the project. It is recommended that this type individual fill out the last form because the questions are such that field personnel may not have access to the answers.

Many of the questions on the first two forms are identical. The engineer filling the one out at the end of the project now has those interim reports to help with the memory in filling out the final report. The Project Performance Factor from the questionnaires will be calculated in this way:

$$PPFq = I(PPFq(Interim)) + E(PPFq(End)) + D(PPFq(District)), \quad (4\text{-}2)$$

where I = Weight of Interim Questionnaires (Reports)
E = Weight of End-of-job Report
D = Weight of District/Central Office Report.

The questions used for each of the questionnaires are located in Appendix C.

Project Performance Factor (From Data)

The proposed model format would collect the test information into a single factor called the project performance factor, data (PPFd). When combined with the project performance factor, questionnaire (PPFq), the final model would include both the qualitative response data and quantitative response data in a compatible form.

$$PPF = m\ PPFq + n\ PPFd, \tag{4-3}$$

where m and n are overall weights for the two factors.

The factor weights will be identified in Chapter 5. The project performance report would contain records of all the sampling and test information used to establish the Project Performance Factor and the periodic questionnaire results. The Contractor Performance Factor requires a separate determination based on the results of the contractor's performance on a series of projects. Table 4.5 shows elements of different types of construction projects that might be used as quality factors.

Table 4.5. Key Elements to be Measured For Project Quality.

ELEMENT	QUALITY FACTORS
Rigid Pavement	W/C Ratio, Consolidation/density, Joint construction, air content, thickness, finish, strength, curing
Bituminous Pavement	Compaction Density, Asphalt Content, Gradation, Surface smoothness, thickness, asphalt properties, aggregate quality, stability, void ratio, and skid resistance.
Bridge Deck	Consolidation/density, rebar cover, w/c ratio, density, mix temperature, curing, air content, strength, vibration/placement, and form work
Structural Concrete	Consolidation/Density, w/c ratio, curing, strength, air content, rebar placement/cover, vibration/placement, form work, and temperature control
Base Course	Compaction/Density, gradation, thickness, moisture content, aggregate quality, uniformity, drainage
Embankment	Compaction/Density, moisture, material quality, uniformity, drainage

In the Interim Report, a conceptual system was offered which was predicated on taking test results of items rigidly following certain guidelines as shown in Table 4.5. The system lumped those items under a heading of "shopping list" items, and tied the tests on the items to a "contractors' list," which included equipment, workmanship (labor), and vendor (materials). This system proved to be too complicated once the QBPR was taken to the field for testing and validation.

So the decision was made not to use the formula in the Interim Report for the calculation of PPF_d (pp. 92,93) for the following reasons:

- Most state DOT's do not employ a sophisticated enough data system to have all the test results needed in one location. Therefore, it would take an extraordinary amount of work to get the results divided into the correct categories (group the test results under the appropriate item number) for use as shown in the Interim Report. It is possible that SiteManager will help in this regard
- Every project is different. Many projects have large paving, structures, and earthwork components. Therefore the decision was made to use a "shopping list" comprised of the tests performed on the top pay items, dollar-wise or volume-wise. It was thought that this method would customize the model to each individual project.

FINAL MODEL

Model Coefficients and Weights

The following is a discussion of the development of the final model, specifically the weights and concurrent coefficients in the final model.

PPF_q

The calculation of PPF_q was simple once the weights for the different quality factors were decided upon. The percentage of positive responses from the appropriate section of the questionnaire was multiplied by the weight assigned to the factor represented by the questions in that section. The weights were determined using the results of the Industry Survey, empirical methods, and the number of questions in each section relative to the whole.

Returning to the Industry Survey, conducted in Phase I, there were eight factors ranked; Personnel, Project Management/Control Skills, Financial Considerations, Schedule Adherence, Contractor Organization, Experience with this type work, Plant and Equipment, and Final Product. For purposes of calculating PPF_q ,these were reduced to five factors.

This was accomplished by combining "Experience with this type work" with "Personnel," and dropping "Final Product," and "Financial Considerations" from this part of the equation. "Financial Considerations" was dropped from the study entirely. It is the belief of the team that the purely financial condition of the contractor can be handled separately, either by a surety, or by the DOT, preferably not both. "Final Product" was assigned to the PPF_d portion of the equation where it can be measured by testing and measurements.

The rankings of the eight factors by industry in order of importance to quality are as follows:

1. Project Management/Control Skills 16.1%
2. Personnel 15.5%
3. Final Product 14.9%
4. Experience with this type work 14.6%
5. Plant and Equipment 10.4%

6.	Contractor Organization	10.1%
7.	Schedule Adherence	9.9%
8.	Financial Considerations	8.5%

Once the factors are reduced to five, these percentages become relative weights, not percentages, because they don't add up to 100 percent. They add up to only 76.6 percent. The column on the right shows the percent of the new whole (without the two dropped factors).

Once the eight had been reduced to five, and the values prorated, the percentages were as follows:

I.	Personnel	30.1%	39.3%
II.	Project Management/Control Skills	16.1%	21.0%
III.	Schedule Adherence	9.9%	12.9%
IV.	Contractor Organization	10.1%	13.2%
V.	Plant and Equipment	10.4%	13.6%

The percentages of the number of questions dealing with each factor on the questionnaire are as follows:

VI.	Personnel	22%
VII.	Project Management/Control Skills	44%
VIII.	Schedule Adherence	16%
IX.	Contractor Organization	14%
X.	Plant and Equipment	4%

When one looks closely at each question, and the relative importance of each question, it is obvious that the questions are not all of equal importance. For instance, though "Plant and Equipment" has only two questions (4 percent), the two questions are extremely important. Conversely, "Project Management/Control Skills" has 22 questions (44 percent), but many of these questions must be seen as less important individually, but important in understanding the overall quality of the job.

Also, it is the opinion of the team that "Schedule Adherence," at this time has become more important than the respondents realize. Most of the owner's respondents were mid-range DOT managers. Very few of the respondents were from the level that they would be the individuals receiving the political outfall of a late project, or even a project that is not late, but has gone on too long in the eyes of the motoring public and politicians.

For reasons such as these, the team did not simply use the rankings to blindly assign weights to the different factors. The weights resulting from consideration of all known influences were inserted into the portion of the model, which calculates PPF_q. These weights are as follows:

I.	Personnel	.30
II.	Project Management/Control Skills	.20
III.	Schedule Adherence	.20
IV.	Contractor Organization	.20
V.	Plant and Equipment	.10

$\underline{PPF_d}$

In order to derive an accurate measure of the quality of the finished product, the measuring and testing done on the materials and workmanship had to be monitored. Therefore, the pay items which were most prominent on the project were used as a "shopping list" to measure the quality of the materials and workmanship of the entire project.

The task was then to determine how to (or whether to) weight the different items being monitored to ensure the best possible representation of the entire project. Six different methods were tried.

Items could be weighed according to the cost of the item relative to the cost of the other "shopping list" items, according to straight rank (most expensive item weighted X, second most expensive item weighted X-1, third most expensive item weighted X-2, etc.), or not at all.

Also, it was thought that a failed test was more important than a negative answer to a typical questionnaire question. Therefore, the model was tested using a weight of 1.7 for each failed test in order to bring a "good" score (.8 for 2 failed tests in 10) to the poor range (.66 for two failed tests in 10). The model was also tested with no such weight.

The six methods tested for the calculation of PPF_d are as follows:

A. The items weighted by cost, without adjusted percent within limits (PWL) using the 1.7 multiplier.
B. The items weighted by rank, without adjusted PWL.
C. The items weighted by cost with adjusted PWL.
D. The items weighted by rank with adjusted PWL.
E. All test results combined into one ratio with adjusted PWL.
F. All test results combined into one ratio without adjusted PWL.

The result of the tests was that the model was just as accurate at identifying the quality of a project using all test results and not altering the factor weights as by using any of the other methods. With SiteManager, all test results will be available. Therefore, model development continued using F above, "All test results combined into one ratio without adjusted PWL."

PPF

The Project Performance Factor (PPF) was determined by adding the weighted values of PPF_q to the weighted values of PPF_d . The Industry Survey showed that the respondents felt that the "Final Product" was worth approximately 15 percent of the whole as far as measuring the quality of a project. Since the "Financial Considerations" item was deleted from the equation, a prorated value was calculated, that being 16.3 percent.

The team gave this item a slightly larger weight based upon the following logic:

- It is extremely important to make the model as objective and unbiased as possible and this portion of the model would be almost totally objective, so a larger weight given to this item would add to the model's overall objectivity.
- Methods in current use such as CONQUAS use these types of results as a stand-alone measure of construction quality.
- For these reasons, a weight of 0.20 was assigned to the Measurement and Testing portion of the model, PPF_d. Thus, the final equation for the model is:

$$PPF = .2(PPF_d) + .8(PPF_q) \tag{4-4}$$

Model Validity

Without supporting data, pure validation of the model is not possible; however, the following comments are appropriate on validation of the model. To maintain content-related validity an appropriate number of tests, or data samples, is needed for each variable. The personnel and project factors (included in the PPFq) rely on periodic sampling rather than a single 'end of job' evaluation. Their inclusion was based on fact finding in focus groups and the literature. The final product (PPFd) variable will be based on a representative sampling from project records. Content-related validity will exist in the model.

Criterion-related validity is an important consideration. Content-related validity is the extent to which the scores from the subjective and objective factor scores are related to the factors they represent. Repeated measures by different raters of the same data will provide assurance that the ratings are repeatable. How well they truly measure personnel or project management contributions to quality performance will require an independent measure for comparison. It may prove impossible to truly get criterion validation for this portion of the model.

The most important validation will be construct validity: This is the extent to which the scores (PPF) describe or measure the aspects that are not directly measurable and will be accomplished by requesting supporting project data from high- and low-quality projects. The ability of the model to score high- and low-quality projects correctly will be measurable and provide the validation desired. The designation of group membership (high- or low-quality project) will be at the discretion of the DOTs providing data for analysis.

COMPANY PERFORMANCE RATING

The most challenging aspect of the model is how it will be used to rank, evaluate, classify, or code a contractor's performance. Once the field performance data are collected, and the appropriate score has been determined, the contractor's performance must be determined. Assuming the project performance factor will be as described above, a contractor factor (CF) will need to be calculated to combine all the contractor's work into a single factor.

An unweighted CF:

$$CF = \frac{\sum PPF}{n}, \qquad (4\text{-}5)$$

where n is the number of projects,

or Cost Weighted (WCF)

$$WCF = \frac{\sum (PPF \times PV)}{\sum PV}, \qquad (4\text{-}6)$$

where PV is the the individual project value.

These simple factors will be used to determine an overall ranking. Comparison of contractor factors would enable a DOT to at least determine if the contractor was above or below the average of all contractors.

These simple factor calculations need to be compared on a group of projects to determine the sensitivity of the data with respect to project value. A second sensitivity check will be made with regard to the appropriate number of projects to be included. Suggestions have been made that several years may be needed to accumulate a sufficient number of projects. There are some limits, however; if there are 20 data points in the CF, then a contractor may be able to have poor quality performance for an extended period of time, and the factor will not reflect the poor performance. Likewise, for a contractor who is improving over time, a large sample size will not reflect the contractor's most recent improvements. For contractors who perform only two contracts per year with the DOT, this would take a large time period to occur. For contractors performing 10 or more contracts per year, the plateau would be achieved sooner. To compare contractors by class or size may also be desired. These are questions that only an analysis of actual data will provide.

If each sample size were the same (say, n=5), then it would be simple for any contractor to be compared against others. That will not be the case, so the most obvious situation would be for the DOT to establish an expected minimum quality performance level and create a lower control limit. If a contractor falls below this minimum cutoff, then they can be disbarred from bidding, or their capacity rating can be reduced significantly. The types of penalties are not considered in detail at this time.

QUALITY AS A FACTOR IN PREQUALIFICATION

Prequalification is the predominate system currently in use, but there are many variations for determining contractor work capacity. The QBPR system used strictly as a prequalification element would leave traditional capacity factors intact. A minimum cut-off in Figure 4.5 would exclude a contractor from bidding. The minimum cut-off would be at any place deemed appropriate by the agency. Figure 4.5 shows a minimum cut-off, the area labeled "unacceptable," based upon a two-standard-deviation shortfall from the peak of the normal distribution curve.

The Missouri model discussed in Chapter 2 uses the standard deviation of the annual data collected to determine the boundaries in the model; therefore, the upper and lower cutoffs are different each year.

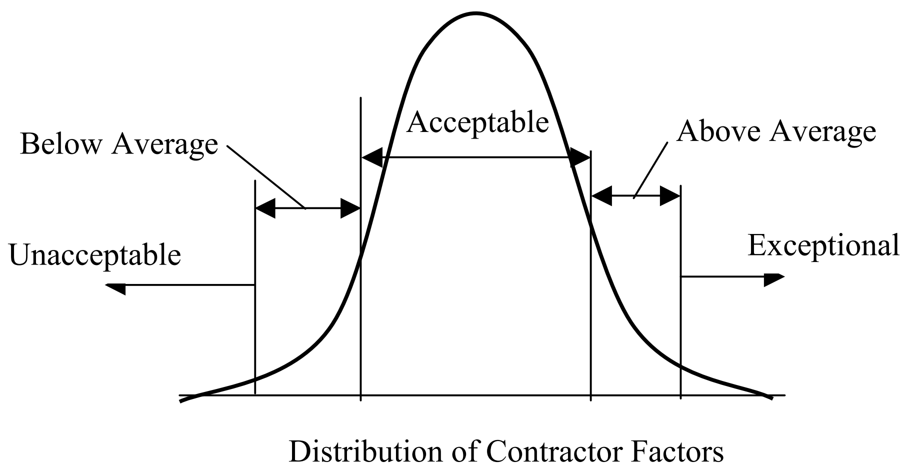

Figure 4.5 Use of QBPR in Qualification.

Capacity Formula Application

Where contractors are assigned a capacity factor, and their ability to bid work can be impaired or improved, the contractor rating factor can be established from the distribution. Work capacity ratings are often set on the basis of evaluations similar to those considered by the QBPR system. Since most DOTs periodically re-evaluate the contractor's capacity rating, the opportunity would exist for the contractor to improve this rating if the contractor has a poor project result. Concerns of sample size and retention of data have been discussed. Traditionally, the capacity rating is a function of the contractor's financial standing, usually expressed as working capital or a related measure and an ability factor. Ability factors in current practice have some features similar to the QBPR factor.

Use as a capacity factor multiplier could also be developed. Figure 4.6 illustrates the use of the total distribution of rating factors. The sample parameters and the assumed population parameters would both need rigorous statistical analysis before such a proposal would be viable. Population testing parameters and similar requirements would need to be tested and evaluated with data from the DOTs; however, this demonstrates an objective approach to using the outcome of the contractor evaluations.

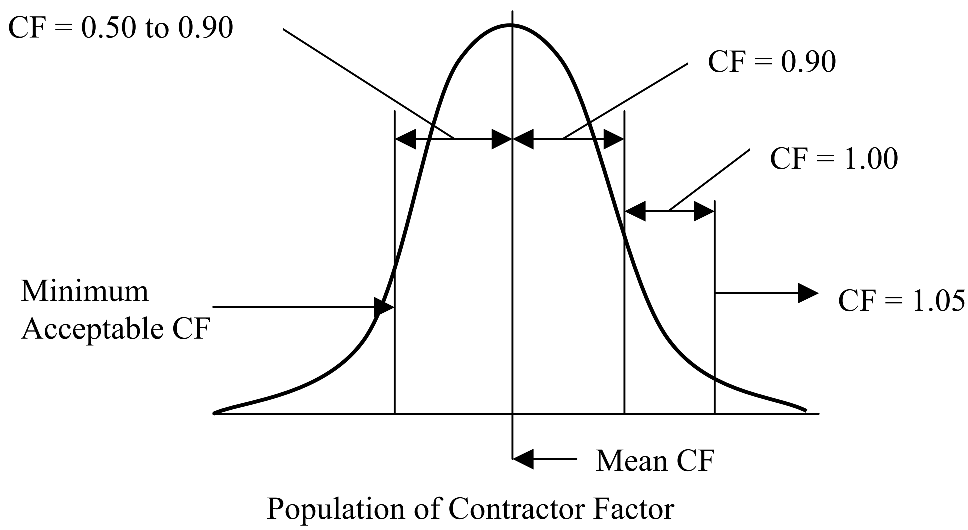

Figure 4.6 Hypothetical Model for Capacity Reduction Factors for Contractor Factor Regions.

Note that this would enable a contractor to hypothetically increase capacity rating if performance is consistently outstanding.

QUALITY AS A FACTOR IN BIDDING

The contractor factor is also a concept that can be applied to the multiple criteria bid (A+B+C) process. The "C" factor would be some product of the CF factor and a monetary amount based on the contract amount and possibly other factors. Some of these other factors could be life-cycle costs, maintenance costs, and three-R costs on projects that do not meet the design life (some sort of state average would be necessary here). The "C" factor, like the "B" (time) factor in A+B bidding, would be an artificial monetary amount added to the "A" (actual bid price) factor to help determine the low bidder using quality as a factor. Of course, the smaller the "C" is, the lower the amount added to the contractor's bid, and the better for the contractor.

A distribution of "C" values as a function of the contractor-rating factor could be generated. The "cost" could be established as the DOT's average life-cycle maintenance cost for the work being bid. This suggests that it would be possible to determine a correlation between a particular contractor's quality function and the impact the contractor's work would have on the life cycle costs of the project.

While this would best reflect the reality of poor construction, determining the correlation between a contractor's quality performance rating and life-cycle maintenance costs is beyond the project scope. As an interim measure, it also would be possible to factor average maintenance costs as a function of contractor quality ratings. This assumes poorer quality-rated contractors' projects require higher maintenance. The added bidder cost would reflect the anticipated impact of lower-quality construction. Unfortunately, low-quality contractors might begin to reduce their costs in part A or underestimate completion time in part B to remain competitive; however, their ability to do this in the long term would be doubtful. Better-quality contractors theoretically could bid somewhat higher and receive the benefit of a lesser amount being added to their bid. This alternative could be examined on a pilot basis using just A+C.

Hypothetical Example. Contractor A has a contractor (quality) factor (CF) of 91 quality points. Contractor B has a CFof 88 quality points, and Contractor C has a CF of 97 quality points. The DOT has installed an amount of $10,000/CF points for this project.

The bids are opened, and the bids are: A - $2,175,000
B - $2,200,000
C - $2,225,000

The effect of the "C" factor can be seen in Table 4.6.

Table 4.6. Effect of the "C" Factor.

CONTRACTOR	BID AMOUNT	QUALITY PTS.	$/QUALITY PT.	"C" FACTOR	TOTAL BID
A	$2,175,000	91	$10,000	$910,000	$1,265,000
B	$2,200,000	88	$10,000	$880,000	$1,320,000
C	$2,225,000	97	$10,000	$970,000	$1,255,000

Contractor C, though submitting the highest bid, gets the project because of an established record of excellence, which is reflected by a high Contractor Factor (CF).

OTHER MODEL APPLICATIONS

The two example applications, for qualification and bidding, are not the limits to the use of a quality-based factor. Other uses include:

- A number to be used in a "Quality Index" for use in determining whether a contractor should be qualified to bid. This would be useful for prequalification or non-prequalification states.
- Quality Factor to be used to set penalty levels for substandard work..
- Quality Factor to be used to set retainage rates. Higher quality would result in lower retainage on DOT projects.
- A Quality Index for determining when a contractor should be held in default or debarred in the middle of a qualification cycle.
- Incentive/Disincentive Index.

- On rare or special projects when contractors are short listed, only those with indices over a certain level would be invited.
- An index to set bonding requirements. This could result in lower bids from those contractors who could pay less in bonding. This could be a project factor, a contractor factor, or both.

SUMMARY

One of the primary goals of the research is to develop a flexible system that can meet the various types of contractor qualifications used by the DOTs. Fundamental to each potential use for a QBPR system is the preliminary model of the factors to be used. The proposed project factor evaluation and contractor factor processes have been introduced. The major chapter focus was on the evolution and considerations of various models and model components. The proposed integrated model represents implementation of concepts from pure questionnaire models and product audit models into a single project rating. Data availability, sources, and 'workability' within most DOT qualification systems have been discussed.

CHAPTER FIVE

DATA COLLECTION AND ANALYSIS

INTRODUCTION

The data used to produce and validate the QBPR system model were collected from DOTs in four states: Pennsylvania, Florida, Iowa, and Indiana. The data obtained from the participating DOTs consisted of two different sets of information: project personnel completed a questionnaire (completed projects were chosen), and the pass or fail results of tests performed on the materials and workmanship of the project were collected. These two forms of data were compiled for projects in four project types: ACC pavements, Bridges (structures), Combined Projects (more than one major element), and PCC projects. The resulting values for the questionnaire and the testing data were assigned weights as described in Chapter Four to calculate a project performance factor (PPF). For Pennsylvania, data were consistently provided on a selected contractor to permit evaluation of that contractor's quality indicator, known as the contractor factor (CF). The straight (not cost-weighted) method described in Chapter Four was used to derive the CF.

DATA GATHERING

Project personnel filled out questionnaires that are scored according to a response key to develop the project performance factor from the questionnaire (PPFq). The other data element was the performance factor from the data (PPFd) that reflects the results of all initial testing performed on materials and workmanship in the project. Retests were excluded from analysis.

The questionnaires filled out by project personnel were collected by two methods. The investigators obtained the majority of the data during scheduled visits with the District Construction Office or a Resident Construction Office. A meeting would be scheduled with project personnel from several projects from that district. While at the meeting, the investigator explained the process and was available to answer questions and take comments as the individuals filled out their forms. This was particularly valuable in the early stages of data collection. Modifications to the questionnaire to improve clarity could be performed on the basis of these meetings, and as time progressed, there were fewer and fewer questions asked. The final questionnaire (the questionnaire designed for use at the end of the project) was used for all data collection. A smaller number of questionnaires were completed and submitted by DOT project engineers who were mailed the form along with a brief set of instructions on completing the questionnaire.

The second data element proved more challenging to collect in an effective manner. There is a great disparity among the states as far as project record management and data storage. Florida, for instance, was able to provide the results of every test performed on a project by simply printing out the Construction Quality Report (CQR) from a computer program that keeps project personnel abreast of materials and workmanship testing throughout the life of the project. Pennsylvania had a similar system that required more manual evaluation than Florida to obtain the same results. Iowa and Indiana were not as automated and required manual review of project files for test data reports and summaries. This process was tedious and required extensive review of lab reports to ensure that double counting and undercounting were avoided. In order to derive the PPFd, the investigator asked Pennsylvania, Iowa, and Indiana personnel for test results or records, while Florida was able to provide a CQR printout.

DATA ANALYSIS

The proposed model required modification in content prior to executing the overall data analysis scheme. The model originally assumed that active projects would be examined. In collecting data for the project, archive projects were a more available choice, but some modification to the factors would be needed. Each state included in the research was reviewed individually. Pennsylvania and Florida were used as the primary points of analysis to develop the methodology and are reported in more depth. Iowa and Indiana analyses were performed after the model was fully developed. Their results are reported in a more concise fashion.

Model Adaptation

The model was discussed in detail in Chapter Four. The proposed model had four primary components: interim quality questionnaire results, final project questionnaire reports from the project personnel and the district's perspective, and the data from testing. Since the projects used for evaluation of the model had all been completed, the PPFq (Interim) could not be utilized. Also, the decision was made that the PPFq (District) would not be pursued at this time. This leaves only the PPFq (End) to represent the PPFq elements of the original equation. For the purposes of data analysis and model validation, Equation 4-3 then becomes:

$$PPF = m\,(PPFq\ (End)) + n\,(PPFd). \qquad (5\text{-}1)$$

Model Weight Factor Rationale (m and n)

As explained in Chapter Four, in placing the values of m and n into equation (5-1), the investigators used their own experience, recommendations of industry and information collected from the original focus group meetings. The questionnaires completed by Focus Group participants discussed in Chapter Three ranked quality of the "final product" as the third-most-important consideration of the eight options, with an equivalent weight of approximately 15 percent of the whole. "Plant and Equipment" was ranked as the fifth-most-important consideration, worth approximately 10 percent of the total. There are two distinct aspects of "Plant and Equipment": quality of the materials and workmanship produced, and sufficiency/reliability. Assuming the value of these two aspects can be split evenly without introducing any appreciable error, five percent can be shifted to the data aspect. Adding the five percent due to the quality of the materials and workmanship produced by the plant and equipment to the 15 percent due to the final product gives a total of 20 percent (n=0.20). This was in agreement with the experience and knowledge of the team. The equation for this phase of the research project was then:

$$PPF = 0.80(PPFq\ (End)) + 0.20(PPFd). \qquad (5\text{-}2)$$

Unfortunately, without having interim project questionnaires and a final district questionnaire, no evaluation can be performed to evaluate the distribution of the 0.80 into weights for these two elements. If, however, an approach used by one DOT to evaluate interim and final reports were used as a 'first best estimate,' then the weights would be approximately 0.50 for the interim project reports, 0.20 for the final report, and 0.10 for the district level report.

The Approach

The model was evaluated using data collected from four states. While every attempt was made to ensure the data were collected in a rigorously consistent manner, the uniqueness of the states suggested alternative approaches. This allowed for additional analysis to be performed in some cases and revised the expected analysis in others. In the following sections, the details of the analysis done in each state will be presented followed by a comparison of the data between states and finally an overall evaluation of the data.

The States

Thirty projects were analyzed in Pennsylvania, fifteen in Florida, twelve in Indiana, and seven in Iowa. The initial data set in Indiana totaled 20 projects; however, eight projects were discarded for various reasons such as: final records could not be located or split sources of data could not be reconciled (district office and main office records). At the time of the visits to Indiana many of their records were being transferred to electronic files. Replacement projects were not available or suggested based on the criteria for projects. Iowa's practices for packaging their contract work content was unique among the states examined and a limited sample was collected to compare consistency with the other DOT results. Their uniqueness was that their contracts tend to be highly dominated by one type of work. For example, it would be uncommon to find earthwork and paving in the same contract. These would be separate contracts. Projects evaluated included Asphalt Cement Concrete (ACC) paving, Portland Cement Concrete (PCC) paving, bridge, and combination projects, i.e., projects that had major paving and bridge elements. Scheduling meetings at the district offices where several projects could be evaluated at the same instance was used for Pennsylvania and Florida. Indiana, due to its remote location from the research team, was treated differently. The researchers elected to request a specific list of projects to review and, as noted earlier, project archive files were reviewed individually. Iowa contracts are characteristically unique in terms of their formulation. Most projects are phased and contracted according to phase; therefore, any PCC paving project will be made up almost entirely of PCC paving. Earthwork and any other structural work were most likely completed under a separate contract prior to this contract being awarded. The data for Iowa projects is highly focused relative to the other DOT's projects.

Pennsylvania

The data for Pennsylvania were evaluated by grouping data in several different ways. The information is presented as separate reports on how the model performed when the data were divided into each grouping. The data will be stratified and examined according to districts, project types, DOT rating, and contractor. Statistical analysis is provided later in this chapter.

Projects Grouped by District

Table 5.1 is the summary data for the projects grouped according to district in which the project was executed. There appears to be a significant disparity in the average scores when the data is grouped by district. The PPFd scores are relatively consistent from district to district, which suggests that material and workmanship quality are fairly consistent. The source of variation is the PPFq. The PPFd is purely a measure of the results of the various tests performed on the materials and workmanship on the project subject to the same standard specification. The PPFq, on the other hand, is a measure of the answers given by the field personnel to the questionnaire portion of the model, and, regardless of question clarity, interpretation will always provide additional variation.

District Four personnel gave answers that scored their projects at an average of 0.760, but this number is highly influenced by the worst PPFq reported being included with a small sample of projects. Clearly, the contractor on this project did not perform in the manner expected, although the materials and workmanship were not the lowest reported. Other district average scores range between 0.861 and 0.935, resulting in the average PPF (the weighted sum of the PPFd and PPFq) for all districts ranging from 0.802 (District Four) to 0.945 (District Nine).

District Nine had the highest PPFd and the highest PPFq. The influence of the contractors in a district may be the primary cause of district variation. District Four had the lowest PPFq, but there were two districts with lower PPFd scores.

Projects Grouped by Project Type

Grouping the projects by the project type was done to examine the relative differences among the scores. The researchers assumed that the evaluations would be somewhat random; that is, both good and poor scores were possible in each type of project and no single type of project would be scored significantly different from the others. Table 5.2 displays the data arranged according to work type.

There is disparity in the average scores when the projects were grouped by project type. The project personnel who worked on ACC paving projects seemed happiest with the contractors' work, giving them an average PPFq of 0.915, while the project personnel who worked on PCC paving projects seemed the least satisfied with their projects, scoring contractors with an average PPFq of 0.833. When evaluated statistically, there is a significant difference between the ACC and PCC pavement results; however, given the disparity in the class sizes and stratification in ACC pavements, no decisive analysis could be performed to demonstrate this trend. It should be noted that separation of the evaluations by work type is not inconsistent with current qualification methods.

Table 5.1. Pennsylvania Projects Grouped by District.

Project	District	PPFq	PPFd	PPF	Avg. PPFq	Avg. PPFd	Avg. PPF
O21115	2	0.966	0.856	0.944			
O22142	2	1.000	1.000	1.000			
O27051	2	0.748	1.000	0.798	0.894	0.929	0.901
O21118	2	0.752	0.797	0.761			
O25070	2	0.946	0.939	0.945			
O22143	2	0.907	0.926	0.911			
O23029	2	0.942	0.986	0.951			
O42259	4	0.637	0.903	0.690			
6006 - #1	4	0.763	0.997	0.810	0.760	0.968	0.802
6006 - PS2	4	0.805	0.988	0.842			
O43228	4	0.836	0.983	0.865			
SR 191-02B	5	0.792	0.951	0.824			
SR 78-029	5	0.980	0.955	0.975	0.892	0.967	0.907
O54059	5	0.904	0.996	0.922			
O91092	9	0.989	0.987	0.989			
O91040	9	0.953	0.984	0.959			
O91086	9	1.000	1.000	1.000			
O91602	9	0.953	1.000	0.962			
O91701	9	0.990	1.000	0.992			
O91710	9	0.975	1.000	0.980	0.935	0.986	0.945
O92081	9	0.783	0.999	0.826			
O92086	9	1.000	0.991	0.998			
O92101	9	0.875	1.000	0.900			
O91065	9	0.964	0.972	0.966			
O91716	9	0.963	1.000	0.970			
O95023	9	0.964	0.971	0.965			
O93131	9	0.746	0.912	0.779			
104165	10	0.741	1.000	0.793			
102144	10	0.900	1.000	0.920	0.861	0.988	0.886
103069	10	0.942	0.963	0.946			

The PPFq scores appear to have no relationship with the PPFd results. This is desirable in that it shows that two distinctly different measurements are being taken. One could conclude that the percentage of passing tests (the actual quality of the materials and work) has no effect on how project personnel grade the contractor's execution of the work.

Table 5.2 Pennsylvania Projects Grouped by Project Type.

Project	Type Project	PPFq	PPFd	PPF	Avg. PPFq	Avg. PPFd	Avg. PPF
O21115	ACC Pavement	0.966	0.856	0.944			
O22142	ACC Pavement	1.000	1.000	1.000			
O21118	ACC Pavement	0.752	0.797	0.761			
O25070	ACC Pavement	0.946	0.939	0.945			
O22143	ACC Pavement	0.907	0.926	0.911			
O42259	ACC Pavement	0.637	0.903	0.690			
SR 78-029	ACC Pavement	0.980	0.955	0.975			
O91602	ACC Pavement	0.953	1.000	0.962			
O91701	ACC Pavement	0.990	1.000	0.992	0.915	0.957	0.923
O91710	ACC Pavement	0.975	1.000	0.980			
O92086	ACC Pavement	1.000	0.991	0.998			
O92101	ACC Pavement	0.875	1.000	0.900			
O91065	ACC Pavement	0.964	0.972	0.966			
O91716	ACC Pavement	0.963	1.000	0.970			
O95023	ACC Pavement	0.964	0.971	0.965			
104165	ACC Pavement	0.741	1.000	0.793			
103069	ACC Pavement	0.942	0.963	0.946			
SR 191-02B	Bridge	0.792	0.951	0.824			
O91040	Bridge	0.953	0.984	0.959			
O91086	Bridge	1.000	1.000	1.000	0.886	0.987	0.906
O92081	Bridge	0.783	0.999	0.826			
102144	Bridge	0.900	1.000	0.920			
O27051	Combination (B/A)	0.748	1.000	0.798	0.869	0.994	0.894
O91092	Combination (B/A)	0.989	0.987	0.989			
O23029	PCC Pavement	0.942	0.986	0.951			
6006 - #1	PCC Pavement	0.763	0.997	0.810			
6006 - PS2	PCC Pavement	0.805	0.988	0.842			
O43228	PCC Pavement	0.836	0.983	0.865	0.833	0.977	0.862
O54059	PCC Pavement	0.904	0.996	0.922			
O93131	PCC Pavement	0.746	0.912	0.779			

Projects Grouped by DOT Rating

In addition to responding to the surveys, the DOT personnel were asked to provide a relative score of "good," "average," or "poor" to the overall project quality. This grouping is provided in Table 5.3. As expected, the “good” projects had the highest average PPFd and PPFq, yielding the highest PPF. The PPF for the “good,” “average,” and “poor” projects were 0.930, 0.899, and 0.813, respectively. There were some individual exceptions to this trend, but the averages were true to form.

Table 5.3. Pennsylvania Projects Grouped by General Ratings.

Project	DOT Rating	PPFq	PPFd	PPF	Avg. PPFq	Avg. PPFd	Avg. PPF
O22142	Average	1.000	1.000	1.000			
O21118	Average	0.752	0.797	0.761			
SR 78-029	Average	0.980	0.955	0.975			
O92086	Average	1.000	0.991	0.998			
102144	Average	0.900	1.000	0.920	0.885375	0.95475	0.89925
O23029	Average	0.942	0.986	0.951			
6006 - #1	Average	0.763	0.997	0.810			
O93131	Average	0.746	0.912	0.779			
O21115	Good	0.966	0.856	0.944			
O22143	Good	0.907	0.926	0.911			
O91602	Good	0.953	1.000	0.962			
O91701	Good	0.990	1.000	0.992			
O91710	Good	0.975	1.000	0.980			
O92101	Good	0.875	1.000	0.900			
O91065	Good	0.964	0.972	0.966			
O91716	Good	0.963	1.000	0.970			
O95023	Good	0.964	0.971	0.965	0.9176111	0.979167	0.929922
103069	Good	0.942	0.963	0.946			
O91040	Good	0.953	0.984	0.959			
O91086	Good	1.000	1.000	1.000			
O92081	Good	0.783	0.999	0.826			
O27051	Good	0.748	1.000	0.798			
O91092	Good	0.989	0.987	0.989			
6006 - PS2	Good	0.805	0.988	0.842			
O43228	Good	0.836	0.983	0.865			
O54059	Good	0.904	0.996	0.922			
O25070	Poor	0.946	0.939	0.945			
O42259	Poor	0.637	0.903	0.690	0.779	0.94825	0.81285
104165	Poor	0.741	1.000	0.793			
SR 191-02B	Poor	0.792	0.951	0.824			

Several things could contribute to these exceptions: one factor might be that some people are simply harder to please than others; however, it seems that a more feasible reason for these exceptions, or errors, or residuals, is that some project personnel answered the questions literally and some did not. This is very important, since the questions were all asked as yes-no questions. From the comments of the participants at the meetings where these questionnaires were filled out, many of the people take a “well, most of the time” approach to the question, while some answer everything in literal terms. It is for this reason that guidelines were developed for the answering of the questions. These may be seen in Appendix C.

A key factor to consider when examining this particular grouping is that there is no way to check the overall rating assigned by the DOT personnel. They may have assigned an "Average" project into the "Good" category or a "Good" project to the "Poor" grouping. For example, project 025070 was rated "Poor" but has a PPF score of 0.945. Persons suspected of miscoding the ratings were difficult to track down for verification of their responses. Even with some apparent problem data points, the analysis of the Pennsylvania data shows there is a clear, distinct, and consistent difference between the scores of the average PPFd, PPFq, and PPF based on the DOT's overall appraisal of the project, although statistical analysis showed no statistically significant difference between good and average projects in Pennsylvania. This is explained further in the Statistical Analysis section of this chapter.

Projects Grouped by Contractor

The Central Office of the Pennsylvania Department of Transportation was asked to choose a contractor to track with the model. This contractor, referred to as "Chosen Contractor," was selected because he works in most districts in Pennsylvania. He is very versatile, working as the prime contractor for projects in all project-types of interest to this study. The contractor is one of the state's best contractors and enjoys a very good reputation statewide. This fact was not known by the investigators until well into the process, but other data suggests that a good contractor will generally perform the at the same level consistently, while contractors of lesser caliber will have more erratic performance records. Table 5.4 shows the data reduction in this grouping.

As would be expected given "Chosen Contractor's" reputation, scores were significantly higher on average than those of the other contractors as a group. This means that not only did the project personnel consistently evaluate the average "Chosen Contractor" project highly, but the test results also bore out that the quality of the material and workmanship was better on the average also. This result is important to a fundamental aspect of this research and demonstrates that contractors could be grouped consistently. This is a facet of the model that will be exploited later.

There are a number of interesting questions raised by Table 5.4:

Is the "Chosen Contractor" a beneficiary of their good reputation, which has a value to them when PPFq scores are tabulated? Why is "Chosen Contractor's" PPFq for "Average" projects the same as for "Good" projects while the PPFq scores for the other contractors as a group increase as one would expect from the "Average" score to the "Good" score? Are "Average" "Chosen Contractor" projects actually that much better than an "Average" project done by another contractor?

Table 5.5 provides a slightly different grouping of data by stratifying the Ratings and Contractors. A closer look at the PPFd, which is a totally unbiased indicator, reveals an interesting phenomenon. The average PPFd for projects labeled "Average" was 0.955. However, for those projects labeled "Average," but constructed by the "Chosen Contractor" the PPFd was 0.972. Those projects labeled "Average" and constructed other contractors as a group received an average PPFd of 0.937. The average PPFd for projects labeled "Good" was 0.979. The PPFd for projects labeled "Good" constructed by "Chosen Contractor" was 0.984. Those projects labeled "Good" and constructed by all other contractors as a group received an average PPFd of 0.957.

Table 5.4. Pennsylvania Projects Grouped by Contractor.

Project	DOT Rating	Contractor	PPFq	PPFd	PPF	Avg. PPFq	Avg. PPFd	Avg. PPF
O21118	Average	Other	0.752	0.797	0.761			
SR 78-029	Average	Other	0.980	0.955	0.975			
102144	Average	Other	0.900	1.000	0.920			
6006 - #1	Average	Other	0.763	0.997	0.810			
O22143	Good	Other	0.907	0.926	0.911			
103069	Good	Other	0.942	0.963	0.946	0.836	0.947	0.858
O43228	Good	Other	0.836	0.983	0.865			
O25070	Poor	Other	0.946	0.939	0.945			
O42259	Poor	Other	0.637	0.903	0.690			
104165	Poor	Other	0.741	1.000	0.793			
SR 191-02B	Poor	Other	0.792	0.951	0.824			
O22142	Average	"Chosen”	1.000	1.000	1.000			
O92086	Average	"Chosen”	1.000	0.991	0.998			
O23029	Average	"Chosen”	0.942	0.986	0.951			
O93131	Average	"Chosen”	0.746	0.912	0.779			
O21115	Good	"Chosen”	0.966	0.856	0.944			
O91602	Good	"Chosen”	0.953	1.000	0.962			
O91701	Good	"Chosen”	0.990	1.000	0.992	0.922	0.981	0.934
O91710	Good	"Chosen”	0.975	1.000	0.980			
O92101	Good	"Chosen”	0.875	1.000	0.900			
O91065	Good	"Chosen”	0.964	0.972	0.966			
O91716	Good	"Chosen”	0.963	1.000	0.970			
O95023	Good	"Chosen”	0.964	0.971	0.965			
O91040	Good	"Chosen”	0.953	0.984	0.959			
O91086	Good	"Chosen”	1.000	1.000	1.000			
O92081	Good	"Chosen”	0.783	0.999	0.826			
O27051	Good	"Chosen”	0.748	1.000	0.798			
O91092	Good	"Chosen”	0.989	0.987	0.989			
6006 - PS2	Good	"Chosen”	0.805	0.988	0.842			
O54059	Good	"Chosen”	0.904	0.996	0.922			

This leads to other observations and questions:

The materials and workmanship on an "Average" "Chosen Contractor's” project seems to be better than an “Average” project done by another contractor. Is “Chosen Contractor” actually handicapped by his reputation? Is the expectation, by the DOT personnel, of a “Chosen Contractor's” project higher than that for other contractors? Does this result in his having to achieve a higher degree of excellence to earn the same "Good" or "Average" ranking as a competitor? Unfortunately, these questions cannot be answered by this research.

Table 5.5. Pennsylvania Projects Grouped by Rating and Contractor.

Project	DOT Rating	"Chosen"	PPFq	PPFd	PPF	Avg. PPFq	Avg. PPFd	Avg. PPF
O21118	Average	No	0.752	0.797	0.761			
SR 78-029	Average	No	0.980	0.955	0.975			
102144	Average	No	0.900	1.000	0.920	0.849	0.937	0.866
6006 - #1	Average	No	0.763	0.997	0.810			
O22143	Good	No	0.907	0.926	0.911			
103069	Good	No	0.942	0.963	0.946	0.895	0.957	0.907
O43228	Good	No	0.836	0.983	0.865			
O25070	Poor	No	0.946	0.939	0.945			
O42259	Poor	No	0.637	0.903	0.690	0.779	0.948	0.813
104165	Poor	No	0.741	1.000	0.793			
SR 191-02B	Poor	No	0.792	0.951	0.824			
O22142	Average	Yes	1.000	1.000	1.000			
O92086	Average	Yes	1.000	0.991	0.998	0.922	0.972	0.932
O23029	Average	Yes	0.942	0.986	0.951			
O93131	Average	Yes	0.746	0.912	0.779			
O21115	Good	Yes	0.966	0.856	0.944			
O91602	Good	Yes	0.953	1.000	0.962			
O91701	Good	Yes	0.990	1.000	0.992			
O91710	Good	Yes	0.975	1.000	0.980			
O92101	Good	Yes	0.875	1.000	0.900			
O91065	Good	Yes	0.964	0.972	0.966			
O91716	Good	Yes	0.963	1.000	0.970	0.922	0.984	0.934
O95023	Good	Yes	0.964	0.971	0.965			
O91040	Good	Yes	0.953	0.984	0.959			
O91086	Good	Yes	1.000	1.000	1.000			
O92081	Good	Yes	0.783	0.999	0.826			
O27051	Good	Yes	0.748	1.000	0.798			
O91092	Good	Yes	0.989	0.987	0.989			
6006 - PS2	Good	Yes	0.805	0.988	0.842			
O54059	Good	Yes	0.904	0.996	0.922			

PPFd vs. PPFq

In an earlier examination, an observation was made from a table regarding the relationship between PPFd and PPFq. Figure 5.1 is a scatter plot of the paired data; no consistent relationship between PPFd scores and PPFq scores is evident. This can be interpreted as the actual quality of workmanship and materials, as tested, having no effect on the scores calculated from questionnaire answers. It is also reasonable to imagine a contractor who does the high quality of work but is not always the timeliest, the most cooperative, or the one who does the best job of documentation.

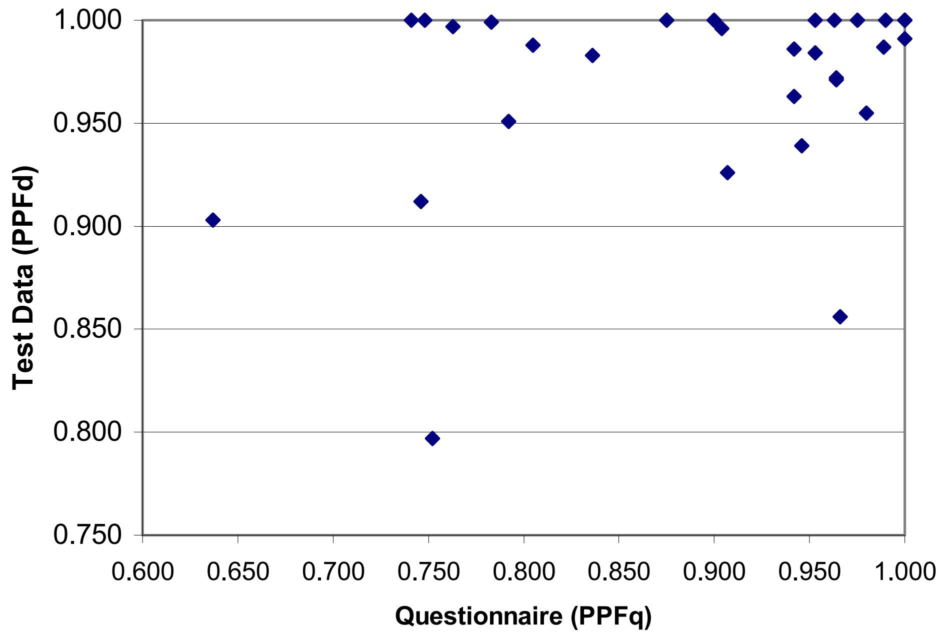

Figure 5.1. Questionnaire Scores v. Test Results.

The Contractor Factor

The Contractor Factor (CF) is taken as the average of all the contractor's PPF scores for the time period under consideration. Table 5.6 lists the performance of "Chosen Contractor" in five districts over a five-year period (1994-1999), and a PPF was generated for each of the nineteen (19) projects analyzed. The final CF for the contractor was 0.934. This would be the index number for this contractor if this model were used for this time period.

Florida

The Florida test data were more complete than that provided from other states because the investigators were able to obtain the results of every test performed on every project from the DOT database. This provided an opportunity to compare the model results using all of the tests to the results using the "major items" approach utilized in the analysis of the data from other states. Recall that the "major items" approach involved using the results of the tests performed on the major pay items, determined by dollar volume, or overall work volume as an indicator of the level of quality for the entire project. The Major Items Approach would have been the most logical approach when this investigation started; however, with the progress made in the AASHTO *Site Manager* project control program, it is a viable option to simply use all test results to calculate the Project Performance Factor – Data (PPFd). The investigators took this opportunity to analyze this option and compare it to the "major items" approach.

Table 5.6. Pennsylvania Data – "Chosen Contractor" CF Data.

Contract	District	PPFq	PPFd	PPF	Rating	Project Type
O22142	2	1.000	1.000	1.000	Average	ACC Pavement
O92086	9	1.000	0.991	0.998	Average	ACC Pavement
O23029	2	0.942	0.986	0.951	Average	PCC Pavement
O93131	9	0.746	0.912	0.779	Average	PCC Pavement
O21115	2	0.966	0.856	0.944	Good	ACC Pavement
O91602	9	0.953	1.000	0.962	Good	ACC Pavement
O91701	9	0.990	1.000	0.992	Good	ACC Pavement
O91710	9	0.975	1.000	0.980	Good	ACC Pavement
O92101	9	0.875	1.000	0.900	Good	ACC Pavement
O91065	9	0.964	0.972	0.966	Good	ACC Pavement
O91716	9	0.963	1.000	0.970	Good	ACC Pavement
O95023	9	0.964	0.971	0.965	Good	ACC Pavement
O91040	9	0.953	0.984	0.959	Good	Bridge
O91086	9	1.000	1.000	1.000	Good	Bridge
O92081	9	0.783	0.999	0.826	Good	Bridge
O27051	2	0.748	1.000	0.798	Good	Combination (B/A)
O91092	9	0.989	0.987	0.989	Good	Combination (B/A)
6006 - PS2	4	0.805	0.988	0.842	Good	PCC Pavement
O54059	5	0.904	0.996	0.922	Good	PCC Pavement

CF = 0.934

Projects Grouped by Project Type

The Florida projects were divided according to project type and evaluated using both the "major items" approach and using all test results. The complete data reduction can be seen in the tables in Appendix C and a complete statistical analysis can be found later in this chapter.

Using Major Items Approach

There was a significant and consistent disparity in the average group scores when the projects were grouped by project type. Florida data was distributed into three project-type groups. These were 1) ACC Concrete Pavement, 2) Bridge, and 3) Combination (Bridge and ACC Pavement). ACC Paving projects, consistent with Pennsylvania were rated higher than other grouped projects, with an average PPFq of 0.920. Bridge projects contractors achieved an average PPFq of 0.897, while combination projects scored an average of 0.762. The PPFq results seem to have no correlation to the PPFd results, which is consistent with Pennsylvania data.

Using Results of All Tests

The PPFq results are the same, regardless of whether the Major Items approach or all test results were used to determine the PPFd. The PPFq results still seem to show little correlation to the PPFd results, though the disparity was not as pronounced. PPFd scores for the ACC Pavement projects (average 0.967) were still lower than those for bridge projects (average 0.990) even though the PPFq scores for ACC Pavement (average 0.920) were higher (bridge average 0.897).

Projects Grouped by DOT Rating

As expected, the "good" projects had the highest average PPF when all test results were used. The PPF for the "good," "average," and "poor" projects were 0.926, 0.916, and 0.743, respectively. When the "major items" method was used, the results were slightly different, with the "average" project getting a PPF of 0.917, while the average "good" project received a PPF of 0.916, and the "poor" project received a PPF of 0.724. Florida data were biased toward "good" projects. Thirteen of the 15 projects in Florida were rated "good," with only 1 each rated "average" or "poor." The "average" project achieved a perfect 1.000 PPFd (zero materials and workmanship test failures among the major items checked) which skewed the results, pushing the PPF higher than normal for an "average" project. See the tables in Appendix C.

Use of All Test Results v. "Major Items" Approach

The use of all test results on the 15 projects caused an overall inflation of the PPF. As stated earlier, the PPFq remains unchanged. The data can be reviewed by seeing the tables in Appendix C, which compare the results when using the "major items" approach to the results using all test results. These tables show that of the 15 projects studied, 11 of them experienced a higher PPF when the results from all tests were used to calculate the PPFd than when the "Major Items" approach was used. The average project that experienced a higher PPF when using the results from all tests experienced a PPFd that increased by 4.3 percent and a PPF that increased by 0.9 percent. When all projects were considered, the average PPFd increased by 3.2 percent, and the average PPF increased by 0.6 percent.

The largest increase on any one project was 14.7 percent for the PPFd and 2.5 percent for the PPF. Explanations for the PPF being consistently higher when all test results are used are as follows:

1. There are several tests on relatively minor pay items, which seldom fail. Among these are several items for which the only "test" is whether or not the item has been properly stamped or whether the item is on the Qualified Products List. These are one-time tests performed at the beginning of the project, which collectively would likely have a pass rate of 100 percent. Including these minor or peripheral tests in the evaluation will inflate the scores overall but would not have any influence on comparisons.
2. When an item is a small part of a project, it is often part of a subcontract. The subcontractor who, for instance, only lays 100 feet of pipe might tend to take more care to do that 100 feet correctly than a contractor laying a mile of pipe as part of a larger contract. Since there will only be probably one test performed, the subcontractor can focus on passing that one test more easily than the contractor required to consistently pass the inspections over a mile of pipe.

Indiana

Projects Grouped by Project Type

There were two project-type groups in the Indiana data set: ACC Concrete Pavement and PCC Pavement. The PPFq scores for ACC Paving projects were again observed to be higher than PPFq for PCC 0.856 and 0.821, respectively. The PPFq results seemed to have no tie to the PPFd results since the PPFd scores for the ACC Pavement projects were consistently lower than those for the PCC projects, averaging 0.853 to the PCC projects' 0.979. This is also consistent with evaluation of project data in other states. There are several tables of Indiana data in Appendix C.

Projects Grouped by DOT Rating

As expected, the "good" projects had the highest average PPFd, the highest PPFq, and the highest PPF. The PPF for the "good," "average," and "poor" projects were 0.914, 0.778, and 0.741, respectively. As in Pennsylvania and Florida, there were some individual exceptions to this trend, but the averages were true to form.

Iowa

Projects Grouped by DOT Rating

As expected, the "good" projects had the highest average PPFd, the highest PPFq, and the highest PPF. The PPF for the "good," "average," and "poor" projects were 0.903, 0.710, and 0.716, respectively. Iowa was the only state that did not show a clear, distinct, and consistent difference between the scores of the average PPFd, PPFq, and PPF based on the DOT's overall appraisal of the project. The average PPF for a poor project was higher than that for the average project. The difference between the scores, 0.006 is not great but, nonetheless, is inconsistent with the other states. Possible explanations for this are as follows:

Iowa is represented by a small data set of seven projects represented; there are two projects in each of the average and poor ratings. Also, there is one construction project, rated "poor" in Iowa, which is unique to the whole research project. The project has a perfect (1.000) PPFd, indicating zero tests on material or workmanship quality, which fell outside of tolerance. This same project has the lowest PPFq (0.542) of any of the 64 projects researched. The team further researched this project and found that the project personnel had ample reason for rating the project poorly. Having such an unusual project as part of the data shows that the contractor's management practices are clearly evaluated separately from the materials. The circumstance just described is a strong argument for using the input of both the questionnaire and the test results in determining a project's quality rating. The tables showing Iowa data groups are in Appendix C.

Comparing the States

The four states chosen for analysis are not only diverse geographically, but they are also diverse in their approach to contracting and design for highway construction. Florida, for example, has almost no PCC paving projects, while Iowa has more PCC paving projects than ACC paving projects. Indiana has numerous bridge projects but submitted none for analysis though requested to do so.

Iowa's approach to letting highway construction contracts is unique and tied to their philosophy of encouraging and supporting many small contractors instead of a few large ones. This means that their contracts are very one-dimensional; it is quite common for them to let a contract for the earth work portion of a highway project as a single contract in a construction season (year) and let the paving portion of the work as a separate contract the next construction season (year). This means Iowa projects are quite limited in scope and more sharply focused than the typical project evaluated in the research. The "major items" analysis for Iowa projects would be very short—occasionally only one or two items.

There are several significant attributes shared by the states. Each state already has a system of rating contractors, and each state, due to AASHTO's influence, performs the same tests on material and workmanship quality. With these similarities, the research team was able to review 64 projects from the four states, and the results of the data analysis have been used to generate a model that is easy to use and accurate.

The following tables (5.7-5.12) should allow the reader to see the similarities and differences in the four states in the areas of project type, DOT evaluation of the contractors' work, and test results. While specific scores are different, the relative rankings are consistent between ACC and PCC projects, with ACC usually having the higher evaluation.

Table 5.7. Four States' DOT Evaluation of Contractor Quality By Project Type.

PPFq				
Item	Florida	Pennsylvania	Indiana	Iowa
ACC	1 (.920)	1 (.915)	1 (.856)	
Bridge	2 (.897)	2 (.886)		
Combination	3 (.762)	3 (.869)		
PCC		4 (.833)	2 (.821)	1 (.762)

Table 5.8. Four States' Project Test Results By Project Type.

PPFd				
Item	Florida	Pennsylvania	Indiana	Iowa
ACC	2 (.937)	4 (.957)	2 (.853)	
Bridge	1 (.979)	2 (.987)		
Combination	3 (.930)	1 (.994)		
PCC		3 (.977)	1 (.979)	1 (.924)

The data set is less than ideal for two reasons: the first is that the states do not all have the same philosophy when it comes to pavement design and contract administration. These differences are documented earlier and lead to gaps in the data, as can be seen in the tables above. The second is that some of the states seemed reluctant to submit poor projects for analysis. This, plus the fact that a higher-quality contractor was chosen by the DOT for contractor tracking, leads to an imbalance in the number of “poor” projects as compared to “good” projects. It may also be the case that there are actually more good and average projects than poor projects being constructed in these states; however, a more positive perspective of these disparities is that the model has the opportunity to demonstrate its robust ability to properly evaluate contractors in these varied conditions.

Table 5.9. Four States’ Project Performance Factors By Project Type.

PPF				
Item	Florida	Pennsylvania	Indiana	Iowa
ACC	1 (.923)	1 (.923)	1 (.855)	
Bridge	2 (.913)	2 (.906)		
Combination	3 (.796)	3 (.894)		
PCC		4 (.862)	2 (.853)	1 (.794)

Table 5.10. Four States’ DOT Evaluation of Contractor Quality By DOT Rating.

PPFq				
Item	Florida	Pennsylvania	Indiana	Iowa
Good	1 (.908)	1 (.918)	1 (.908)	1 (.884)
Average	2 (.896)	2 (.885)	2 (.755)	2 (.680)
Poor	3 (.684)	3 (.779)	3(.682)	3 (.660)

Table 5.11. Four States’ Project Test Results By DOT Rating.

PPFd				
Item	Florida	Pennsylvania	Indiana	Iowa
Good	2 (.948)	1 (.979)	1 (.934)	1 (.978)
Average	1 (1.00)	2 (.955)	3 (.868)	3 (.829)
Poor	3 (.884)	3 (.948)	2(.978)	2 (.939)

Given these facts, it is necessary to analyze the data as is. Any time the model failed to score the projects according to the ranking assigned by the DOT, there were extenuating circumstances. In some cases, the state being analyzed had only one or two of a certain type of project (small data set), while in other cases, a score was unique, such as the project, detailed earlier, in which the materials and workmanship tested at 100% within limits, but the other aspects of the project were abysmal. However, it was noted in one project that approximately 1 year after the completion of a "poor" project, the DOT acknowledged their testing parameters were incorrect, and, ultimately, all tests passed. It did not appear that the project evaluator for this research was aware of that final determination. These type projects are simply rarities that will occur occasionally but are not worthy of any change to the model, which is designed to handle the preponderance of cases, not the rare exception.

Table 5.12. Four States' Project Performance Factors By DOT Rating.

PPF				
Item	Florida	Pennsylvania	Indiana	Iowa
Good	2 (.916)	1 (.930)	1 (.914)	1 (.903)
Average	1 (.917)	2 (.899)	2 (.778)	3 (.710)
Poor	3 (.724)	3 (.813)	3(.741)	2 (.716)

Table 5.12 illustrates the effectiveness of the model compared to the rankings of projects assigned by the DOTs. In many cases, as anticipated, borderline projects can shift either way and not create a major disturbance. The difference between Florida's "Good" and "Average" projects and Iowa's "Average" and "Poor" projects is not great. The one element in question that cannot be validated by any means is the accuracy of the ratings assigned by the DOTs.

STATISTICAL ANALYSIS

An extensive statistical analysis was performed on the data and the results are shown in Appendix D. In order to do a statistical analysis, something has to serve as the baseline – the correct answer or number. For these analyses, the DOT rating was treated as inerrant, which in reality it cannot be due to bias and other human limitations. The persons rating the DOT projects as "good," "average," or "poor" were not the individuals who participated in the PPFq phase of the research. The highlights of the analysis follow:

- A dot plot of all the PPF scores showed the anticipated trend. See Figure 5.2.

- An ANOVA run on all data for PPF was illuminated further by a Tukey's Pairwise Comparison. All ANOVA were run for a 95 percent confidence interval (CI). These tests showed that there is a significant difference between "good" and "average" projects and between "good" and "poor" projects, but there was no significant difference between "average" projects and "poor" projects, though there is enough variation in the data to show a noticeable difference. The small data set of "poor" projects seems to be a factor here.

- An ANOVA run on all data for PPFq was illuminated further by a Tukey's Pairwise Comparison. These tests showed that there is a significant difference between "good" and "average" projects and between "good" and "poor" projects, but there was no significant difference between "average" projects and "poor" projects, though the overlap was so slight that for anything less than a 95 percent CI, there would surely be a significant difference.

- An ANOVA run for PPFd was illuminated further by a Tukey's Pairwise Comparison. These tests showed that at the 95 percent CI, there is no significant trend. In other words, PPFd, the test result data, has no relationship to the DOT rating of the project.

- A plot of PPFq v PPFd showed no significant relationship between the two values. This had a p-value of 0.062. This means that the DOT personnel's answers to the questionnaire have no relationship to the test results.

- The data for PPFd was then tested to ascertain the difference between the "major items" method and the All Test Results Method of determining PPFd. It was determined that using the All Test Results Method always inflates PPFd. The rate of inflation was not entirely consistent. The model's performance is not affected by which of these methods is used.

- An ANOVA run on the Pennsylvania data based on the contractor doing the work was illuminated further by a Tukey's Pairwise Comparison. The p-value of 0.016 means there is a significant difference between the PPF scores of the "chosen" contractor and the other contractors, and the Tukey's Pairwise Comparison shows only a very slight overlap at the 95 percent

- Another ANOVA run on the Pennsylvania data based on the district in which the project was built was illuminated further by a Tukey's Pairwise Comparison. The p-value of 0.050 means there is a significant difference between the PPF scores earned by contractors from district to district. A look at the pairwise comparison shows that the significant difference is between District Four and District Nine. In the pairwise comparison, there is considerable overlap between the other districts as well as between districts four and nine and the other districts, thus no significant difference. This can be partially explained by the fact that all projects reported by District Nine were performed by the "Chosen" contractor, who is a good contractor. Meanwhile, this contractor performed only one of Four District Four projects.

This analysis also showed that when "District" and "Contractor" are used together in a regression equation, neither is significant, which proves the existence of confounding. Though the trend is obvious, the ANOVA showed no significant difference, though the Wilcoxen's Non-parametric Test does show a significant difference, thus statistical significance.

- An ANOVA run on all data checking the relationship between project types revealed that the project type is confounded with the state. Iowa was found to be significantly different from Pennsylvania (p=0.028). This is to be expected since the Iowa paving projects were all PCC and the Pennsylvania paving projects were mostly ACC. Iowa was also significantly different from Florida (p=0.0593) for similar reasons.

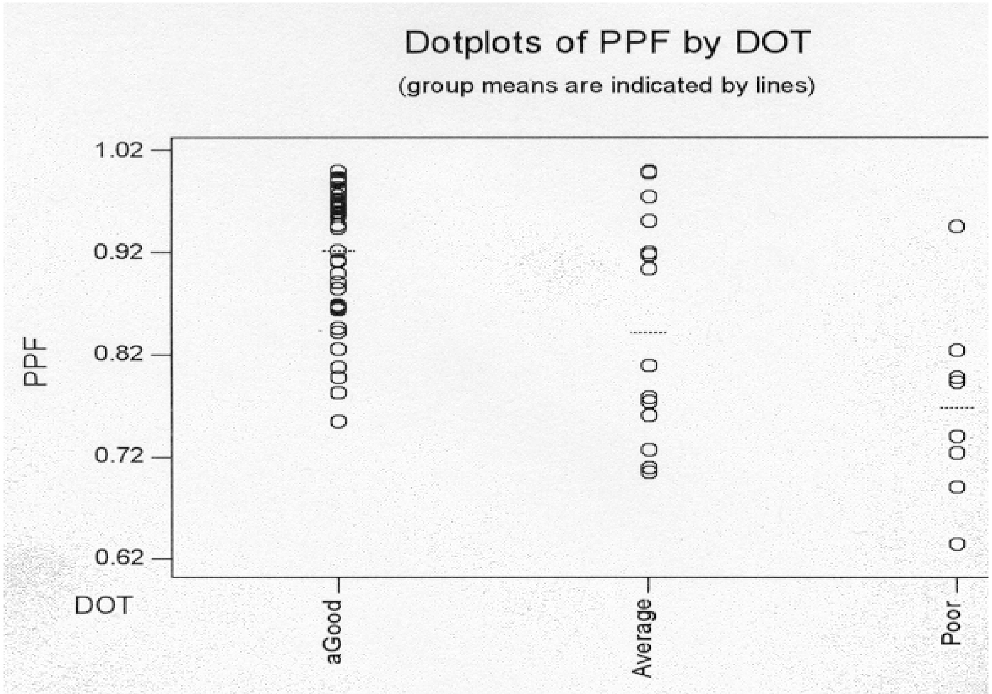

Fig. 5.2. All PPF Scores Showing Anticipated Trends.

Statistical Summary

None of the observations made by the researchers at the conclusion of the study were completely refuted by statistical analysis. There was confounding within the data, but nothing that shouldn't be expected in an analysis with this many variables.

One of the most important confirmations made by the statistical analysis was that there is no relationship between the test results of the workmanship and materials of a project and the DOT rating of the project. This was observed by the researchers prior to the statistical analysis and simply confirms that an owner has more measures of project quality than simply the quality of the end product.

Another important confirmation was that there is no relationship between the test results for workmanship and materials of a project and the score given by project personnel answering questions about the project. This not only confirms the researchers' observation that an owner has more measures of project quality than simply the quality of the end product, but also shows the value of the model in that it is measuring two distinctly independent, unrelated measures of quality and integrating them into a single score.

To get a true picture of how this model works, projects should be tested during the construction phase instead of after completion. This will reduce end-of-project bias from the PPFq and show how the model would work if implemented.

SUMMARY

In the states evaluated, the ACC paving projects received the highest marks from the DOT personnel answering the questionnaire. In no state did that translate into the highest test results. There was no difference from state to state in the rankings of overall contractor quality (PPF) when the projects were divided by project type, other than some states not having all project types represented. It is also a fact that Missouri, whose current system is similar to the proposed QBPR system, reported the same phenomenon; however, they were already examining independent rankings for contractors within their work type qualifications categories.

The data analysis and model validation process showed the QBPR system (model) to be accurate, and easy to use. As part of the data gathering process, participants were asked if they would have any qualms about filling out a questionnaire each month such as the one used for this study. Participants said that doing so would not put an undue burden on them, and several remarked that it would be no increase over what they do now. This response was not expected given the recent increase in paperwork required of DOT Construction field personnel.

The simplicity of the system is found in the fact that there are only two components in the final algorithm. This is possible due to the weighting of the questions and the combining of the three project performance factors taken from questionnaires (PPFq) into one. This model, therefore, is very easy to understand; however, end of project bias in this research is still a possibility due to the lack of interim data.

The accuracy of the model was found to be sound. In most cases, the PPF generated by the model corresponded quite well to the DOT rating of the project, and often when it did not, there was an obvious explanation that verified the worth of the model. In fact, for the overwhelming majority of the projects, it was felt that the model depicted the quality of the project more accurately than either of the two components— questionnaires filled out by project personnel and test results—did alone. The questionnaire was reduced to a binary response pattern to reduce the level of subjectivity. The inclusion of the test results lends an undeniable aspect of total objectivity to the model that will help with not only its accuracy and reliability but also with its implementation.

The final and most compelling conclusion to be drawn from this analysis is that to the owner, the process is a very important component of quality. There were some instances in which the test results were less than stellar, but the DOT still rated the contract highly due to the contractor's attitude of diligence, timeliness, and initiative. The opposite was also true in that on one project where every test result was within tolerance for the entire project, DOT personnel rated the project as less than "good." An interview with project personnel revealed that the contractor was uncooperative, late with submittals, inaccurate with payment records, and showed no sign of a helpful attitude for the entire length of the project.

These things are all part of quality to an owner, which is why every state that currently has a system of rating contractors asks questions based on the process. The QBPR asks those questions also in a more unbiased way and adds the objectivity of the results of tests on the quality of construction materials and workmanship.

Additional Observations

These observations are not conclusions per se from the analysis; they represent key beliefs that developed during the examination of the data and response patterns. The researchers have no method to evaluate these observations but feel they are significant enough to include as a post-script to the summary.

- It is believed that the addition of the PPFq (Interim) and the PPFq (District) will enhance the model by reducing bias and adding information. It would be interesting to see if the clear delineation between project personnel's rating of different project types still would be present if the project questionnaire forms were filled out and submitted on a monthly basis, as intended.
- Poor projects as a percentage of the population are few. It was not clear if DOTs were reluctant to share the data or if few poor project contractors continue to work for DOTs. Missouri's experience provides some insight into this dilemma, and it could be surmised that as a percentage, poor performance is the exception.
- Could it be that in this era of flexibility rather than specialization, that the average DOT technician is still more comfortable working with one material type, like asphalt pavements, than bridges or concrete pavements. Is part of the potential bias due to DOT preferences in materials?
- The analysis might have been more precise if the respondents would answer all questions literally, as intended, and let the investigators adjust the model to render the best results. Guidelines, in Appendix C are prepared to assist in this evaluation.
- The percentage of passing tests (the actual quality of the materials and work) has no effect on how project personnel grade a project.

CHAPTER SIX

IMPLEMENTATION ISSUES

INTRODUCTION

The implementation of the proposed QBPR for contractors is a major undertaking that involves many issues beyond establishing an appropriate measurement technique. The request for proposals listed in Task 7 a number of specific issues to be considered and researched during the development and initial evaluation of the model. The use of the SiteManager program as a platform for implementation has been explored in detail.

The process of competitive bidding on public projects is one that is governed by state and local statutes that require that the award of a contract be made to the lowest "responsive" and "responsible" bidder. A responsive bid matches the terms or requirements for submission given in the request for proposals or bid solicitation. The determination of criteria on what constitutes “responsible” is generally left to agency or authority regulatory procedures. Any discussion relative to the QBPR process requires that the appropriate authority is vested in the agency to implement a performance evaluation process.

INTEGRATION ISSUES

Without recreating all of the variations on qualification systems, several comments can be addressed with regard to integrating the QBPR system with existing qualification procedures. Presently, many agencies use a questionnaire evaluation or report card on the contractor's performance on the project; these may be in prequalification or post-qualification applications. Missouri's system, described in Chapter 2, has many similarities to the system proposed. Their program would be considered a highly detailed process in terms of their questionnaire and evaluation technique, while other DOTs use very simplistic systems. The QBPR questionnaire was developed as a very generic model and would be considered more simplistic. Individual DOTs may feel that they would prefer a specification-based approach to that provided by QBPR, or they may simply add specification questions to the QBPR baseline questions. The intent in development of the proposed system was to select only those questions that were felt to be the most important to evaluating the contractor's overall quality performance. This was determined through the focus group participation and through a ranking questionnaire; therefore, the questions were generic in nature.

The integration paths for existing questionnaire-based systems would be to adopt the system as proposed or adapt the system to a DOT-specific version. Adopting the new QBPR in the current formulation would be a path of least effort. It is recommended that the QBPR be pilot tested in parallel to the DOT's existing questionnaire system to satisfy users that it will provide similar results and feedback. Since contractor evaluations were not in the public domain, and consequently not made available to the researchers, it was not possible for the research team to perform this direct validation check independently. Adaptation would be the most likely choice. The generic nature of the questions can be modified to reflect key timing elements on submissions, completions, and other DOT-specific requirements.

ORGANIZATIONAL AND ADMINISTRATIVE CONSIDERATIONS

Organizationally, few changes would be required for those DOTs who are currently using a performance evaluation questionnaire. In centralized agencies, the responsibility for collecting the evaluations and preparing the rankings would most likely be assigned to the prequalification office or central construction office since the qualification questionnaires and the QBPR scores would both be required to review a contractor's qualification eligibility. In decentralized agencies, the District Construction Office will probably handle this task. For post-qualification procedures, the organizational responsibility would need to be assigned to the contract review committee. They may need to designate an office or department-construction, for example-to maintain the system.

Administratively, depending on the amount of flexibility in their state statutes, the DOT may already have the necessary administrative authority to implement the system. From an administrative burden perspective, the proposed system requires frequent monitoring due to the monthly reports being filed for each project; thus, the use of an automated data collection process would greatly enhance the process and reduce the administrative burden.

- If fully implemented in Site Manager, then the automated data collection system can easily handle the data collection and calculations. The key advantage to this would be the availability of contemporary updated information.
- If the QBPR process is established as a stand-alone manual system, then a web-based data collection system is recommended. Most database systems can accept information streams from a web-based system.
- A completely manual operation of a QBPR system would be very cumbersome and resource consuming, but no more so than the systems currently utilized in some states.

Contractor size and type

Contractor size and type are two issues that are frequent concerns regarding qualification. The size, interpreted to be contract volume per year, would not have much impact from the QBPR system approach because of the general nature of most questions. From the standpoint of impact from multiple projects in the database, larger contractors have an ability to have a larger number of contracts active during a construction season; therefore, one poorly rated project would not have a severe impact on the contractor's CF if the other projects completed in the same time frame earned higher PPF scores. Small contractors could feel a proportionally larger impact. The suggestion for combining data for any contractor was to use a weighted average based on contract volume for each contract, but this is not a perfect solution. For small contractors who perform only one or two contracts per year, little room for correction can be found since their evaluation will be based only on the projects they complete. The literature review of current DOT systems highlighted the records of one DOT where more than half of the qualified contractors in a four-year period only worked on one contract.

One additional concern regarding contractor size is the fear on the part of smaller contractors that the larger contractors begin the process with an advantage because of reputation and notoriety; however, review of data on contractors, provided to the research team, suggested that contractors who performed well did so consistently, regardless of size. Likewise, those that performed poorly were rated consistently in that fashion, so size of contractor from this perspective may not be an important factor.

Contractor type, based on type of work performed, may be more of an issue. The research data showed consistency in rating asphalt paving projects and contractors higher than concrete paving projects. Some limitations in the data collected could be part of the cause, but conversations with DOTs indicate they have similar experiences. Missouri has separate rankings for contractors based on similar concerns.

Qualifications of the agency or individual doing the rating

In determining responsibility of a bidder for a construction contract, there are two important principles. A public works statute gives discretion to an awarding board or body in conducting their evaluation. When the board acts fairly and honestly within the reasonable exercise of a sound discretion, the courts will generally not interfere with the board's award decision. Public contract administration would be hampered greatly if courts were free to second-guess reasonable administrative decisions (Housing Authority of Opelousas, La v. Pittman Construction Company, 264 F.2d 695 (1959)). The Pittman decision involved an assertion by the contractor that the Housing Authority had abused its discretion in awarding the contract to another firm. In describing similar decisions in Louisiana and other states, the court pointed out that an awarding body can consider skill, integrity, judgment, experience, reputation, previous conduct on other contracts, and other factors in determining responsibility. The court stated that ". . . Courts will not substitute their judgment for the good faith judgment of an administrative agency, but an awarding body's administrative discretion must be exercised in a fair and legal way and not arbitrarily. The Board has the right to be wrong, dead wrong; but not unfairly, arbitrarily wrong."

Ensuring discretionary authority, however, must be balanced against statutes protecting the public interest in honest competition in protecting taxpayers from favoritism and high prices in the awarding of public contracts. These provisions "exist to protect citizen taxpayers from unjust, ill-considered or extortionate contracts, or those showing favoritism . . . To depart from these principles would be to open the door to abuses and practices fraught with danger to the welfare of the citizens and taxpayers of municipalities and political subdivisions of the state (43 Am.Jur., Public Works and Contracts, Sec. 45)."

Thus, municipalities and states have broad discretionary powers in determining the lowest responsible bidder, and as long as this power is not exercised arbitrarily, decisions will not be set aside. None of the issues recovered identified any concern regarding the qualification of the persons or agency doing the evaluation. In most cases DOTs have specific requirements for employee qualifications for those in positions of authority. Provided the qualifications committee or panel acts in good faith in their evaluations, it is not likely that there would be a problem.

Appeals Process

Contractors that have been determined to be not responsible have the right to rebut the charges. The United States Court of Appeals in the case of Pittman v. Housing Authority of Opelousas, La, asserted this view. In that dispute, Pittman Construction Company was disqualified from a contract award, based on irregularities in the bid and unfavorable rumors about Pittman that had been reported to members of the Board. Pittman was never informed of these allegations, nor was he invited to meetings where these issues were discussed. The Court made it clear that this practice was unacceptable. It stated "In the light of what fair-minded, reasonable laymen would do, we think that before a Board disqualifies the lowest bidder as not responsible, the lowest bidder has the right to be heard and the Board has the duty to listen on the subject of responsibility." It was further elaborated that it was not expected that "a Board conduct FBI investigations, hold elaborate hearings, adhere to legal rules of evidence, and function as a judicial body."

A case in the California Supreme Court in the City of Inglewood provided similar findings. There, the court ruled: "We hold that prior to awarding a public works contract to other than the lowest bidder, a public body must notify the low monetary bidder of any evidence reflecting upon his responsibility received from others or adduced as a result of independent investigation, afford him an opportunity to rebut such adverse evidence, and permit him to present evidence that he is qualified to perform the contract (City of Inglewood-Los Angeles County Civic Center Authority v. Argo Construction Co. 500 P.2d 601 [1972])."

Appeals processes were found to exist in a large number of qualification systems where the contractor would be evaluated with a performance questionnaire. Normally, the process requires that the contractor sign the project evaluation, with a caveat that the signature only representsthe fact that they have been given the evaluation and an explanation of the ratings. The contractor then has a limited time period to appeal and present information to challenge the ranking. If not satisfied, then the ranking may be appealed to one or more higher administrative levels within the DOT. There is wide variation in the administrative procedures established for appeals. Although not required in the research, documentation to support rankings for each question is recommended. Once a contractor's ranking has fallen below a specified point, they may be placed in a probationary status or disqualified. A probationary step allows the contractor an opportunity to improve his performance with the DOT. Failure to improve during the probationary period should result in disqualification. While some DOTs use their performance ratings in their capacity formula, many others simply use it as a part of the qualifications decision process. Missouri's process was a stepped process of probation before disqualification.

Duration of Disqualification

Many factors can be considered in determining responsibility. These generally fall within the four broad categories of financial capability, managerial and technical ability and experience, performance on projects for the awarding agency, and business practices (Thomas, H. R. and G. R. Smith. NCHRP Synthesis of Highway Practice, Synthesis 190, Transportation Research Board, Washington, DC [1994]). It is helpful to summarize some specific instances that were justified disqualification.

- Refusing to contract with persons and businesses involved in bribes.
- A contractor who engaged in an illegal scheme with a government official to obtain government contracts.
- A contractor who admitted to wrongful bidding practices.
- Repeated failure to pay minimum wages.
- A contractor's delinquency in completing another construction contract.

- Financial weakness and failure to provide the necessary financial information.
- Using an unlicensed subcontractor.
- On a prior identical project, a contractor who intentionally deviated from the contract specifications.
- Previous delays, lack of cooperation, and poor performance.
- A reputation for poor-quality work.

In contrast, there are instances in which a contractor cannot be declared 'not responsible' because of specific actions:

- The contractor employed non-union labor.
- A provision requiring bidders to provide evidence of previous experience with the design configuration of a proposed floating bridge.
- The mere change of a contractor's name.
- A contractor is involved in litigation with the awarding agency on another project (Housing Authority of Opelousas, La v. Pittman Construction Company, 264 F.2d 695 [1959]).

The QBPR system addresses several of the issues directly slated for disqualification above. Deviation from the specification, delays, poor cooperation, poor performance, and poor-quality work are all considered in the formulation. Specifically addressing a time period for disqualification is difficult because there is none that is universally accepted. In general terms, a DOT is free to establish an appropriate and reasonable time period.

The use of annual ratings would dictate a one-year cycle. A logical procedure would be to place a contractor on probation for one year to see if he can improve his performance. If he is unable to improve, then disqualification for a year would be appropriate. Following the year of disqualification, the contractor could be permitted back to bidding projects but remain on probation. If he is successful, then his status could be reinstated to non-probationary; however, if he fails to perform while in this stage, a more severe penalty should result. Missouri, for example, maintains a three-year disqualification period. Timing elements should be considered for each DOT relative to its specific circumstances and review of statutory limitations that may impede their ability to disqualify bidders based on performance review. A number of the administrative rules reviewed did not mention performance reviews.

In a recently completed study from Maine, 17 of 23 respondents indicated they would or could disqualify a contractor from the evaluation rating process. The time of disqualification was less uniform: six said it varied, two prefer to meet with the contractor and have them file a plan of action, two maintain a rolling qualification for disqualification, one waits until a formal challenge is made, one limits work classifications, two disqualify for three years, and one permits requests for reevaluation. Most, 53 percent, reported that contractors needed to improve performance on current projects to improve their ratings, and 29 percent had no improvement process included. Of the 23 respondents, 53 percent also reported disqualifying a contractor. Maine has instituted a two-year hiatus on disqualifying contractors while instituting a performance rating system. Those not using their performance evaluation form for disqualification used the information to improve contractor performance or adjust bidding capacity.

New Companies and Mergers

New companies and mergers present a unique problem to rating systems. They should be given a trial period to establish their ranking or possibly given a probationary status at the beginning. Again, assuming a new company can pass the prequalification and bonding hurdles, there is no effective way to measure its performance on a project. Probation would give the company a time period to demonstrate its ability to perform for the DOT.

A unique issue dealing with disqualification that should be addressed with appropriate language is that disqualification may not disqualify the officers of that company as well. The purpose for disqualifying the officers is to prevent them from re-forming the business assets under a new company name, submit new company qualification paperwork, and continue doing business as usual. By disqualifying the officers in this manner, the likelihood of re-entry is reduced. Considerations must be given to mergers with disqualified companies and similar business activities that would reduce the effectiveness of the QBPR.

Frequency of Rating

There are several approaches to the issue of frequency of rating or measurement. One approach uses interim evaluations tied to specific time periods or requests for evaluations, and these are weighted separately with an independent final evaluation. Most DOTs, however, use an annual evaluation approach to their performance surveys that may or may not be supplemented with progress evaluation measures for projects not completed within the qualification period. The suggested QBPR system combines monthly ratings with an end of project rating; therefore, at any period in time, a current project rating could be obtained. The other concept that appears with frequency of rating is the number of projects to be included in the rating. Lacking the data to fully evaluate this element, the researchers were unable to formulate an opinion.

Normalization, Clearinghouse, and Sharing Information

Comments from many qualification personnel in DOTs suggest that normalization is not of much concern. The records in most states regarding contractor performance evaluation are not public records. In collecting information from contractors for the purpose of qualification, a question regarding contract defaults in the past year or two years for DOT contracts would cause most DOTs some concern. In many instances today, when a qualifications department has a question about a contractor, it simply calls its counterpart in the neighboring jurisdiction and gets an independent opinion. To normalize among all transportation agencies would be very difficult given the wide variation in contractor qualification and competitive bidding philosophy. Currently, the range of qualification practices extends from no formal qualification requirements other than bonds to extensive qualification questionnaires with rigorous performance evaluation systems. Once again, referring to the Missouri system as a similar system to the proposed QBPR system, they chose to develop their rating scheme on their specifications sections. To normalize, equivalency must be established within the specification measures, as well as the formulation of the questionnaires.

Sharing information, unless prohibited by law, occurs today, and QBPR would not likely interfere in that information exchange. A clearinghouse concept for all QBPR collected data may not be possible due to the confidentiality of contractor performance evaluation information. Current administrative regulations in some DOTs do not permit the release of any performance review data. The clearinghouse may be able to post overall rankings, without specific information, that would enable a DOT to review the contractor's performance in other jurisdictions. Sharing also would be enhanced with wider implementation of compatible programs. Even if DOTs adapt the proposed QBPR to their desired evaluation, the information could be cross-referenced from one rating to another.

Impact on Bonding of Contractors

Assuming the specific data collected from the QBPR system is confidential and would not be released to the general public, although overall rankings might be published, bonding companies would not have access to most of the information. Provided their contractor is not in a position to default on a contract, the surety should not be an issue. If the QBPR can be established to provide a compelling reason for contractors to improve their performance, then this would likely enhance the bonding company's position with regard to contractor default rates. Bonding companies in Missouri have solicited the DOT for evaluation data on contractors that they represent.

Legal Implications

In response to the requirement not to be arbitrary in the evaluation of responsiveness, states and other agencies have developed objective criteria to judge responsibility. However, agencies need to be careful in the exercise of numerical attributes. A 1972 decision by the Supreme Court of California illustrates this point. It is in this case that the concept of "relative superiority" is discussed (City of Inglewood-Los Angeles County Civic Center Authority v. Argo Construction Co. 500 P.2d 601 [1972]).

In planning the construction of a new $12 million civic center, the Civic Center Authority Commission of the City of Inglewood sought the services of a construction manager. Agro Construction Co. submitted a bid that was $70,000 lower than Swinerton & Walberg Co. Relative to the financial responsibility portion of the qualification documents, a uniform point system was applied. The highest score attainable was 38, but contractors scoring less than 30 were considered unqualified. Swinerton scored 34, and Agro scored 30; thus, both contractors were deemed qualified.

The contractors were also evaluated on the basis of experience, ability, personnel, workload, and client relations. A uniform scale was again applied. Out of a maximum of 61 points, Swinerton scored 55 points, while Agro scored second with 42 points. The reviewing board recommended the award to Swinerton, stating that "based upon the evaluation scores and interviews, the panel believed the city would obtain excellent construction talent, experience, and other qualities important to the successful completion of the project. Although Swinerton's qualifications were considered to be so superior as to justify its selection, the report did not state that Agro was unqualified." The court stated that "the contract for a public construction project must be awarded to the lowest monetary bidder . . . unless it is found that the lowest bidder is not responsible . . . There is no basis for the application of a relative superiority concept under that section, and if petitioners applied such standard in selecting Swinerton rather than Agro as the contractor the award cannot stand."

Similarly, the City of Manchester, New Hampshire, advertised for the construction of a vocational education center. No date or time of completion was specified in the bid documents. Instead, contractors were invited to propose the number of calendar days they needed to complete the project. Gerard Construction Co. submitted the lowest monetary bid of $7.38 million, with the longest completion time of 730 days. The reviewing board recommended the second lowest bidder, arguing that it offered better value to the city because completion in 730 days would have been beyond the needed completion date. The Supreme Court of New Hampshire rejected this argument, stating that "insofar as Gerard's qualifications have never been questioned, we agree with the trial court's ruling that subsection II (b) provides no authority for considering completion time in determining the low bid" (Gerard Construction Company, Inc. v. City of Manchester 415 A.2d 1137).

The implication to this research is that agencies need to establish the minimum quality score that is acceptable. Unless a contract is advertised as an A + B-type contract, bidders cannot be selected because they provide a better value in terms of quality. Missouri has addressed this issue by establishing ranges within their ranking system that first places a contractor in a probationary status prior to disqualification.

An opinion rendered by one of the nation's top construction attorneys is contained in a following section. Mr. F. Alan Cummings submitted his opinion on the implementation of the QBPR by state transportation agencies.

MISSOURI EXPERIENCE

The experiences of the Missouri Department of Transportation are important to summarize while examining issues of implementation. As described in various portions of the report, their system is a sufficiently close parallel to warrant further examination for implementation issues. The time required to fully develop their system began with a task force that worked from 1991 until 1995. Their results did not generate the results desired, and the system was revisited and redeveloped from 1995 to 1997. Generally, the group was comprised of 12 people representing the DOT and contracting community. While formulating the system, they met on a monthly basis, usually for two days at a time. Individual effort was required and time committed outside of regular meetings difficult to estimate; however, the indication was that for a significant number of participants, the commitment to development time was significant.

Their strategy for contractor development was to invite participation in the early stages. Consequently, participation was highest from the subcontracting community. It was not until after the system was implemented that the prime contractors became more participatory. Other issues on which implementation provides insight are as follows:

- Contracting community did not agree on the system's use for incentive or penalty evaluations or for consideration as an element in a 'best value' analysis similar to an A+B+C system; however, they are considering its use for reducing a contractor's retainage (i.e., outstanding performance rating may result in zero retainage).
- All contractors begin at 100 percent of the scoring system.
- One contract score is sufficient for annual rating. If contractors do more than one contract, then the score is averaged.

- The system is managed and operated separate from their qualifications office.
- Two letters have been received from attorneys that represent contractors placed on probation, but so far, there have been no legal challenges.
- Bonding company reaction seems favorable. Two have requested information and ratings.
- All contracts require partnering. At monthly partnering sessions, issues are discussed, and the contractor has an opportunity to 'fix the problem.' This intermediate evaluation has the same purpose proposed by the QBPR system's monthly evaluation and report.

The Missouri experience suggests that objective style systems are functional but require careful communications, significant up-front planning, and a long-term commitment to making the process work.

SITE MANAGER

SiteManager is a product of AASHTO's construction management system (CMS) joint development project. It is a comprehensive construction project control and management tool currently in use in several states.

The investigators met with the software engineering firm retained by AASHTO to develop SiteManager. The chief software engineer was very encouraging in his analysis of the QBPR system and its prospects for integration into SiteManager. He estimated that the QBPR could be integrated into SiteManager in a relatively short period of time and at a reasonable cost. SiteManager as it currently exists contains all of the information needed to make the QBPR perform at its optimum level. Of course, this is predicated on the DOT using SiteManager in the way intended.

The chief software engineer also suggested that perhaps the best way to validate the integration and implementation of the system would be for the research team to work with the software engineering firm in integrating the QBPR into SiteManager and validate the system on some ongoing DOT projects.

IMPLEMENTATION PLAN

The implementation of a system to measure contractor quality performance will require a step-wise process that utilizes the input and interaction of the contractor community. One element to recognize is that even with template questionnaires and guidelines, the implementation of this system will take an extensive effort. The Missouri experience and trials covered at least ten years.

The following is a sequential process to implement the system. Several of the steps have been discussed above and will not be discussed in great detail here. It is understood that each state has unique statutory requirements and limitations, so the discussion will be at a generic level. It is also understood that some states, due to these statutory requirements, could implement only part of this plan.

1. Establish Team

Once it has been decided that implementation of a quality-based performance rating system is desired within a DOT, the first step is to formulate a combined team of contractors and DOT personnel whose charge will be to develop, proof, and pilot test the system. It is important to include contractor representation for all aspects of contracts that would be included in the quality-based performance rating system. Initial meetings with the contracting community will be needed to describe the purpose and intent of the process. A decision is also needed regarding the status of sub-contractors in the quality performance measurement system. The procedure implemented in the research included only the prime contractor. This phase may require a 6- to 9-month discussion period.

Team Tasks

- Determine what the system will be used for

The first task of the team will be to determine what the QBPR system will be used for. There were several uses suggested in earlier chapters, ranging from simply setting bid ceilings to total contractor qualification and having the rating be a factor in bidding.

- Determine the appropriate form of rating system for contractor performance

The second task for the team will be to determine whether to use the QBPR system or some other system for the purpose chosen, how much of it to use, what parts of it to use, etc. Certainly, rather than start from scratch in developing questions, the DOT's current performance questionnaire (if one is used) and the questionnaire developed in this research, and perhaps detailed questionnaires like the Missouri performance questionnaire, should be evaluated. The research questionnaire approach is fairly generic, while the Missouri questionnaire has general questions as well as specification-based questions in a 10-page document formatted to follow their specification sections. The QBPR questionnaire developed in the research had five major sections:

1. Personnel.
2. Project Management/Control.
3. Schedule Adherence.
4. Contractor Organization.
5. Plant and Equipment.

Other arrangements are possible. For example, Missouri groups their questions as: quality, prosecution and progress, contract compliance, and safety. Many of the same questions are used in both questionnaires, but the questions are grouped differently. A new organization style, as opposed to current performance questionnaire, will differentiate the new system over the old approach to performance evaluation.

Subjectivity of the system will rely on the team's ability to develop measurable and objective questions. If a questionnaire system is used, then the questions can be developed in a "yes or no" fashion and in some cases in "multiple choice" fashion. Missouri's questionnaire is a combination of these two approaches. A fair estimate of the time to allocate to development of a questionnaire satisfactory to both groups, assuming monthly meetings (all day or 8-hour meetings assumed) would be approximately 6 months to one year.

- Determine the suspension procedures

A key to the success or failure of any system developed to measure performance is establishing appropriate penalty procedures. A rating less than or equal to the mean minus two standard deviations would be considered unacceptable performance. Ratings between the mean minus one and the mean minus two standard deviations would be below average performance. Between the mean plus one standard deviation and the mean minus one standard deviation would be acceptable or average performance. Ratings in the mean plus one and mean plus two standard deviation range would be above average. Finally, ratings equal or greater than the mean plus two standard deviations would suggest outstanding performance. If a contractor is found to be in the unacceptable, then they should be eliminated as a qualified bidder as nonresponsive. The group falling into below average performance could be assigned a lowered bid capacity on the basis of its rating.

The penalties can be staged to allow contractors an opportunity to improve their ratings, but also to prevent someone from automatically being eliminated. For example, an overall unacceptable rating would place a contractor on a probationary status for one year. Clearly, to improve a contractor would need to make significant strides when allowed to bid again. Suppose when allowed to bid again the contractor does not improve and again scores in the unacceptable region. At this stage, the contractor would be eliminated from bidding for a specified time period. One or two years would be possible time limits to consider for the first suspension from bidding. After the suspension has been served, the contractor would be placed back on the bidders list on a trial basis. If they again achieve an unacceptable rating, then the suspension period should be increased. Missouri also suspends the individual owners from participation. This prevents them from reorganizing the firm and bidding under a different name.

Another issue regarding the implementation of penalties is performance within categories. Missouri also considers unacceptable ratings within categories of questions as a cause for possible probation or suspension. Each DOT should examine this issue individually.

- Establish appeal procedures

The ratings for each contract in the proposed system would be known on a monthly basis to the DOT and the contractor. A one-week appeal time would be established at the project level for the contractor to meet with the project engineer to attempt resolution of differences. Failing a project-level resolution, a one-week appeal time would be permitted to the next level (assume District level) to give a district engineer or construction supervisor sufficient time to investigate the cause of the disputed rating. Alternatively, for end-of-project ratings, the contractor should have additional time to evaluate the rating and appeal. The contractor should also be required to either file a formal appeal or, without a formal request within the allocated time period, the right to an appeal could be forfeited. This eliminates the performance review as a potential problem in closing out the project records and ensures a procedure for due process. For appeals on ratings, a DOT review committee should examine the facts and suggest a final rating for the DOT. This should occur within a short time period-say two weeks-of the contractor filing an objection to their rating. The State Construction Engineer has the final decision and should review the recommendation from the committee. For contractors, the final appeals can always be filed in the court system if they feel that the process above has not properly evaluated their performance.

- Determine where the ratings will be published

Some states may allow a public publishing of the ratings in a trade journal or even a newspaper, while most will have stricter standards as to where these ratings can be published. In states where public publication is allowed, this may be an effective reward system for the best contractors and an effective encouragement for the less stellar contractors to improve their performance.

- Determine an appropriate rewards system

Some form of formal DOT recognition of the best performers in each category of contractor is suggested. Plaques, trophies, or some other form of public recognition of the contractor's achievement is valuable. Other forms of recognition could be arranged for banquets or news announcements. Financial incentives could also be examined, with each top performer being given a significant cash award for extremely high achievement levels.

- Identify legislative effort to implement system

Each set of state statutes has some form of legislation to authorize the DOT to perform certain works on behalf of the taxpayers. This legislation will need to be examined with regard to the permissibility of implementing this system. In some instances, the initial authorization rules are broad enough to permit implementation within their existing rules. Unfortunately for others, their rules will need to be rewritten to permit this process to be initiated.

A part of this task will also be for the agency to convince the Federal Highway Administration (FHWA) that the system chosen for implementation will work to the FHWA's satisfaction if the planned use of the system is in the area of bidding or contractor qualification. It is the experience of the investigators that it will be up to each state to make its own case to the FHWA for approval of its system.

2. Legislative Effort to Implement the System (If necessary)

Depending upon the statutory requirements of the state and the system chosen for implementation, certain legislative actions may be necessary to facilitate implementation. It is recommended that these be taken care of before proceeding further. It is assumed that the level and nature of possible legislative effort was taken into consideration when the final decision was made as to which system would be used and for what purpose(s).

3. The Pilot Program

The DOT should conduct a pilot program of at least one year to familiarize itself with the system. This would necessitate choosing projects that will be completed in the time frame of the pilot program. It is important that the projects begin and end within the pilot program time period to avoid the problems that the investigators encountered in the research, that being the inability to test the whole system due to the lack of input from all of the required questionnaires. This caused possible end-of-project bias in the original study.

The first ratings should be used to evaluate the system for ineffective questions, misunderstood questions, and suggested improvements. Missouri, for example, found that they wanted to split out their analysis in classes of large, medium, and small contractors. The questionnaire should be reformulated and prepared for implementation. The rating period should represent one-half to one full year of completed projects. If only annual ratings are intended, then many projects may not be finished in the evaluation cycle.

4. Training

Department personnel must be trained in the operation of the QBPR system. Certain logistical aspects of the training would be left to each state to customize to best suit its needs. The overall approach would be contingent upon the strategy of system implementation chosen by the group in its initial decision-making process. If the strategy is to implement the QBPR system as presented in this report, then the DOT has basically two good choices. One is for a consulting team familiar with the system to travel to the state to teach all affected personnel in several sessions over a period of time possibly in a variety of locations. The other is for key DOT personnel to be taught by these consultants and in turn teach the rest of the affected DOT personnel.

If the system as presented in this report is either not used or is altered considerably, then the DOT may want to take on the job of teaching their employees the workings of the system with limited or no help from knowledgeable consultants.

In states that are implementing the SiteManager program, the training should, by all means, be integrated into the SiteManager training. As part of SiteManager training, it is estimated that the QBPR system portion of the training would take no more than an hour. As stand-alone training, it would take closer to two hours.

It is essential to also train any consulting engineers and technicians who are retained for contract administration or any form of construction project control. The training for these consultants should be identical to that given department personnel, and these individuals as agents for the state should be trained in classes integrated with DOT personnel if possible. This will ensure that DOT personnel and Construction Engineering and Inspection (CEI) consultants approach the use of the system in identical fashion.

It is advisable that training also be offered to contractors. This training would not be the same as offered to DOT personnel and CEI consultants. This training would be more along the lines of an information dissemination session than actual training since the contractor personnel will not have to actually operate the system. This session will be for the purpose of letting the contractor know exactly how the projects will be graded. The hope is that better understanding of the system on the part of the contractor will reduce the incidents of contractor claims and complaints.

5. Final Implementation

It is recommended that the program actually be implemented two to three years before it goes into effect. For instance, the QBPR should be utilized to rate all projects beginning with the January, 2003, letting. The contractors should understand that from that point forward, they are, by the quality of their work, building their Contractor Factor (CF), which will take effect (in whatever manner the state decides) on January 1, 2006.

In the initial start-up of the system, all contractors should have the same rating. The contractor overall ratings should be weighted on the basis of contract dollars as suggested in equation 4-5. This assists in comparison of one contractor to another and eliminates the problem of any one project severely damaging a contractor's rating if they happen to have a problem.

In the above example, on January 1, 2006, the system should be up and running. In the interim (January 1, 2003 – December 31, 2005), the QBPR system could simply replace the state's existing contractor rating format and be utilized for precisely the purpose that the current format is used. In this manner, nothing would change on January 1, 2006, except for the publication of the contractor ratings and the implementation of a system that has been in place for three years.

LEGAL OPINION

Mr. F. Alan Cummings has served as counsel for both owners and contractors in a long and distinguished legal career. Mr. Cummings has served as counsel for the Alabama Department of Transportation, defending the state against contractor claims. For many years, he has been the most respected construction attorney in the state of Florida, representing numerous contractors in negotiation, arbitration, and litigation cases involving the Florida Department of Transportation. Intimate involvement on both sides of so many construction contract conflicts gives Mr. Cummings a unique perspective on construction contract law, especially as it pertains to public policy and contracts.

F. Alan Cummings is a resident partner in both the Fort Lauderdale and Tallahassee, Florida, offices of Smith, Currie & Hancock LLP. In January of 2001, Cummings & Snyder, P.A., joined its practice with Smith, Currie & Hancock LLP, where Mr. Cummings had been senior and managing partner from 1986.

Mr. Cummings received his law degree in 1975. During his twenty-five years of practice, he has practiced in the area of contract litigation and counseling. He has handled all aspects of construction disputes from preconstruction and post-award bid disputes to construction litigation on behalf of contractors, owners, subcontractors, design professionals, and sureties. He has extensive experience in litigating delay claims on major construction projects throughout the Southeast.

Mr. Cummings specializes in areas relating to construction, government contracts, and suretyship. His current client representation includes general contractors, subcontractors, sureties, municipalities, and owner-developers nationwide. He has authored numerous articles and is a frequent lecturer on the subjects of risk avoidance and construction claims preparation for institutions of higher learning, public agency seminars, and corporate training sessions.

He is a member of the Forum Committee of the Construction Industry, Public Contract Law, Litigation, and Fidelity & Surety Law sections of the ABA. He is an approved Arbitrator for commercial and construction contract disputes, American Arbitration Association.

Mr. Cummings' legal opinion on implementation issues regarding the QBPR system is contained in the letter he sent the investigator dated March 15, 2001, which is shown in its entirety below.

Dear Dr. Minchin:

Thank you for the opportunity to review and comment upon the Final Report of the Quality-Based Performance Rating System ("QBPR"). The Final Report is quite comprehensive. It is evident that it is the product of much thought, effort and experience. I also was impressed that the Final Report recognizes the many difficulties inherent in the implementation of a QBPR.

There are many states, as well as county and city governmental bodies, that prequalify contractors. These prequalification requirements most often are based on a contractor's available equipment, personnel, experience, and financial and bonding capacity. In other words, they are limited to a determination that a contractor has the wherewithal to perform the work. As I understand the proposed QBPR, the prequalification process would take into account a contractor's competency. A determination of competency would be based upon the many factors suggested in the Final Report.

The legal sufficiency of various prequalification procedures has been tested, and the procedures have passed judicial scrutiny. Accordingly, there is no general body of law that precludes the prequalifying of contractors, although some states have legislatively imposed restrictions. Where prequalifying of contractors exists, or where there has been no imposition of legislative restriction, there would not seem to be a legal impediment to including competency as part of the prequalifying process. Undoubtedly, a state may limit bidders for public projects to those who are responsible and competent. Of course, all potential bidders must be treated alike, and the prequalifying procedure cannot be found to promote favoritism or to discriminate.

Many states have statutory requirements that contain language that public projects must be awarded to "the lowest responsible bidder." The word "responsible" is broad enough to include competency, based on history of performance, as a factor in determining responsibility. In Florida for example, this probably could be done through agency rulemaking and would not require legislative action. On the other hand, and as you are aware, the term "lowest responsible bidder" has been construed to constrain a letting authority from ranking bidders based upon competency once they have been prequalified. In order to use competency in bid evaluation, a legistatlive change would be necessary. Although it did not address competency, the Florida legislature has authorized its DOT to use time of performance in bid evaluation. The additional use of competency could be considered a natural extension of such authorization.

I commend the salutary purpose of your studies and the QBPR. The practicalities of implementation are daunting, but I am sure that you would not have undertaken this task only to be dissuaded by the difficulties.

Accordingly, I wish you good luck.

Sincerely,

F. Alan Cummings
Smith, Currie & Hancock LLP
1004 DeSoto Park Drive
Tallahassee, Florida 32301

CHAPTER SEVEN

SUMMARY AND CONCLUSIONS

SUMMARY

The purpose of this research was to develop a quality based performance rating for transportation construction projects for qualification and prequalification processes. The literature review indicated that several approaches were currently used in other segments of the construction industry, including questionnaires and third-party certifications. A survey of systems currently employed by DOTs revealed elements of the proposed model have been tried in some DOTs, but none has been formulated for broad-based applications. The limiting factor to most of the existing questionnaire-based systems was their high level of subjectivity and no guidance concerning when to put a contractor on probation or suspension. The data and information collected for Chapter Six highlighted the current state-of-the-art considerations for suspensions and other implementation issues. The limiting factors to third-party systems were a lack of a clear connection to improved quality for ISO and too little quality management content for the CONQUAS-style systems.

A typical owner holds that there is more to quality than the "end result." DOT personnel believe, as shown by focus group results, that quality management was as much a part of a quality project as the actual test results available for materials and workmanship. Thus, the proposed model includes both quality management measures and test results.

The researchers collected data from four DOT organizations. This effort faced several limitations that influenced the research but will also influence DOT plans to implement a system. The primary limitations encountered were:

- Paper-based test records and project files made data collection difficult.
- Allowing DOTs to recommend which projects would be evaluated limited the number of poor projects in the data set.
- Prequalification records could not be accessed for use in several DOTs due to the sensitivity of the recorded information. This limited the ability of the researchers to truly classify the past performance of the contractors in the study.

The analysis of the project data provided evidence that the technique can, in most cases, rate contractors into appropriate categories. The review of Missouri's experience also supported the ability of a well-structured questionnaire to properly evaluate contractor performance.

CONCLUSIONS

The quality-based performance rating system was successfully developed and evaluated in this research project, the results of which are published in this report. The following conclusions are drawn from the project:

Contractor performance ratings can be more objective than the current systems. Both the QBPR and the Missouri models demonstrate the effectiveness of adding objectivity to the model.

- The QBPR can be used in qualification or bidding applications.
- Continual development and adjustment is needed as the model is implemented to adjust to local requirements.

RECOMMENDATIONS FOR FUTURE RESEARCH AND DEVELOPMENT

The researchers have found a significant amount of interest in many DOTs to examine the final model for potential implementation. The level of interest would suggest two distinct paths that can be pursued for further development.

1. The model proposed the use of interim questionnaires to avoid end-of-project bias. Missouri requires monthly partnering or team meetings to review performance; QBPR would need to be tested with interim data submissions. If one or two DOTs were interested in participating in a study that tracks the process of implementation, including capture of development costs, the results of this study would assist in providing guidance to DOTs who implement in the future. In addition, use on active projects would aid in tailoring the questionnaire and test data portions further.

   It is therefore recommended that a Phase II be considered for this project. Oklahoma DOT has volunteered to take part in the study in which a DOT project would be selected and the QBPR system would be used to measure project quality from the beginning of the project through the life of the project. A second state, preferably in the west, should be found to participate in like manner.

2. Given increased interest in implementing this type of model, support should also be considered for tailoring a portion of SiteManager to gather responses to the questionnaire portion in addition to summarizing the test results.

   To that end, the investigators visited with the consultant that developed SiteManager for AASHTO. The consultant reviewed the QBPR system model and stated that SiteManager was already designed to acquire and store all of the data needed for the test-results portion of the model, and the questionnaire could be fitted into SiteManager without major difficulty.

It is therefore recommended that AASHTO or NCHRP accomplish the integration of the QBPR into SiteManager either through another phase of this study or through direct contract with the consultant. Testing on this integrated model would need to be done. Oklahoma has also expressed interest in participating in this study because they are implementing SiteManager presently and hope to have it completely implemented as the department's full-time project control program by June, 2001.

There is a third possibility for future work, which is the combination of numbers one and two above. Two states could be chosen and the project could have a two-part plan: (a) Integrate QBPR into SiteManager, (b) Validate the system in two states which already have SiteManager in place by testing a project in each state from beginning to end.

APPENDIX A

THE LITERATURE SEARCH

A. Bibliography

B. Literature Review Summary Report

C. Reference Table

Table 2 – State-By-State Account
- DOT Practices and Procedures for:
  - -Contractor Qualification
  - -Award of Construction Contract
  - -Contractor's Past Performance Appraisal

D. Annotated Bibliography

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LITERATURE REVIEW SUMMARY REPORT

- **Introduction** – Presentation of problems, prequalification is addressed in literature however the quality attribute is merely verbalized instead of actualized.

The term “quality” is mentioned frequently in discussing the attributes and/or potential of a prequalification system. However, evidence proving a relationship between quality and prequalification are not readily available. The ideology is given considerable lip service while in reality nothing and no one has ever definitively linked the two concepts. The remainder of this summary will review the findings of an extensive literature search on the subject of prequalification in general and its relationship to quality in specific. A substantial amount of literature was found to address prequalification but nothing substantive addressed quality and prequalification together.

- **Definition** – Prequalification is …

The definition of prequalification is not steadfast and varies with authors. The following descriptions of prequalification represent the slightly differing views of various authors.

    - Nettleton (1948) – the determination of the responsibility of each contractor to satisfactorily undertake and complete a certain construction project before the issuing of plans, specifications, and proposals. It is an extension of the principle applied to the professions of law, medicine, and engineering in which persons must have a certain understanding of appropriate theory an applicable experience to be licensed for business.
    - Russell (1996) – the screening of candidates based on a set of criteria
    - Taha, Park, and Russell (1993) – the process of determining a contractor’s competence and ability to meet specific project requirements prior to issuing the project plans and specifications for bidding. It can be characterized as a collection of decision-making subproblems.
    - Thomas, Kowadlo, Willenbrock, Hester, and Logan (1985) – the process of determining the competence and responsibility of contractors before they submit their bids.
    - Russell Jeffrey S. and Ahmad, Irtishad (1990) – a process by which an owner evaluates the competence of a candidate contractor to perform the requirements associated with a given project.
    - Latham (1994) – the development of a list of firms that are suitable (having already been qualified which Latham defined as getting on an approved list) for a particular project.

- **Objectives** – Implement prequalification to …

The objective of using a prequalification system for procuring construction contractors can be viewed in several ways. The following listings were presented by the respective authors in literature.

    - list from literature

- Drew and Skitmore (1993) – the objective of prequalification is obtaining the lowest bid at the minimum bidding cost. These authors suggest that a contractor should be prequalified on his historical record of being competitive with his bids.
- Holt, Olomolaive, and Harris (1995) – emphasis presently directed towards encouraging lowest bid should be redirected towards establishing contractor ability for achieving client satisfaction which includes past performance, quality of completed project, etc.
- Hauf (1976) – The purpose of prequalification is the elimination of incompetent, overextended, and underfinanced contractors.
- Diekman (1981) – The four high level objectives of prequalification are limiting cost exposure, evaluating company stability, ensuring quality in the finished product, and evaluating management capability.
- Nettleton (1948) – Prequalification can reduce the number of business failures in construction by minimizing the opportunity to select contractors who have insufficient financing and/or lack experience.
- Russell (1996) – Prequalification focuses on avoiding constructor failure which helps to promote project success.
- Thomas, Kowadlo, Willenbrock, Hester, and Logan (1985) – Prequalification serves three major functions
        - Thomas, Kowadlo, Willenbrock, Hester, and Logan (1985)

- reduce the chance of receiving bids from unqualified contractors
  - prevent incompetent, overextended, underfinanced, and inexperienced contractors from being considered
- Russell (1996)
  - Avoid failure
  - Foster competition
- Latham (1994) – It is intended that the evaluation process will help increase the value per dollar of projects built.
  - responsive v. responsible bidder

The premier objective of prequalification is to discern the responsible, responsive bidder from the bidder who is merely responsive. The terms responsive and responsible carry heavy implications and are defined as follows in the literature.

- Nettleton (1948) – The responsible bidder is one that is able to prove that he is possessed at the specified time of satisfactory skill and knowledge, good integrity, sufficient plant, equipment, personnel, labor and finances to undertake and satisfactorily perform the construction work upon which he wishes to bid. He must also be able to acquire the necessary materials.
- Napier and Freiburg (1990)
  - proposer responsibility – includes conformance with the requirements for participating in the procurement and for executing the work if awarded the contract.
  - proposal responsiveness – includes conformance to the architectural design and building engineering requirements of the project, as well as the qualifications and capabilities of the proposer
- Thomas, Kowadlo, Willenbrock, Hester, and Logan (1985)
  - A responsive bidder submits the appropriate bidding information according to a set of guidelines
  - Responsibility addresses the contractor's ability to complete the work. Examine the following attributes for responsibility
    1. financial strength and resources of the contractor
    2. documented skill of the contractor and subs on previous projects, as well as their requisite skill for the project in contention
    3. judgment, which extends to financial management as well as construction management
    4. overall experience in the construction industry as well as experience of the key personnel who prosecute the work
    5. integrity of the officers to ensure they have not been involved in previous wrongdoing or contract crimes.
    6. previous performance, which evaluates the contractor's quality of construction and ability to complete the project within the goals of time and cost.
    7. ownership of equipment, or the ability to rent or lease equipment, needed to perform the project.
    8. ability to perform in accordance with the contract provisions and provide the required labor and material suppliers
    9. ability to acquire bonding from an established and reputable surety
    10. conformance with the goals and objectives of affirmative action plans.

Responsive – the bidder meets the criteria set forth in the request for proposals or bids

Responsible – the bidder is found to be capable both financially in physically in terms of ability, labor, and equipment.

- **Factors of Interest**

There are many relevant questions that can be asked during prequalification inquiries but a few critical factors should be addressed for certain. There is some agreement between authors about crucial information necessary to make an informed prequalification decision but each of them present them differently.

  - Holt, Olomolaive, and Harris (1994)
- contractor's organization
- financial considerations
- management resources
- past experience
- past performance
  - Russell (1990) – awarding authorities should verify that the bidder…
- has adequate financial resources or the ability to secure them
- has the necessary experience, organization, and technical qualification; available personnel resources; and has or can acquire the necessary equipment to perform the proposed contract
- is able to comply with the required performance schedule or completion date, taking into account all existing commitments
- has a satisfactory record of performance, integrity, judgment, and skills
- Russell (1996) – the most important factors are…
- constructor experience
- stability
- employee qualifications
- capacity
  - Thomas, Kowadlo, Willenbrock, Hester, and Logan (1985)
- financial statement
- plant and equipment
    - can be evaluated through
      - common sense
      - ownership or opportunity to rent
      - state DOT intuition
    - equipment adequacy can be evaluated quantitatively by
      - ability factors
      - quantify equipment values and include them in the MCR formula
- organization and experience
    - experience includes organizational experience, organizational structure, and organizational efficiency
    - experience can be evaluated qualitatively by
      - letters of recommendation from owners, suppliers, engineers, and architects
      - listing of key managerial personnel and corresponding construction experience
- performance reports – assessed for workmanship, cooperation, and diligence in executing the work. Can be used to isolate poor contractors and not necessarily lower their MCR.
- integrity
- EEO
  - Warwick (1992)
- the use of nonconformance reports was suggested for consideration in the letting of future projects.
- The submission of a quality manual prior to bidding so their sufficiency can be evaluated prior to bid and the record kept on file.
- Napier and Freiburg (1990)
- proposer responsibility
- proposal responsiveness
- proposal price

- **Developing Evaluation Criteria**

- Napier and Freiburg (1990) – The authors clearly endorse the idea that each project has unique priorities and goals and therefore each project must necessarily have different evaluation criteria. They proceed to set up some broad guidelines for developing a criteria listing. Factors included …
    - must reflect the most important features of the project.
    - items sensitive and critical to the project that would distinguish a successful project from a failure.
    - must address the more general, fundamental aspects of the project rather than definitive details.
    - must address features of the project left open to the proposers' individual design solutions.
    - must address features of proposals that can be reasonably judged for quality and for which values can be assigned.
    - must be consistent with the size and complexity of the project.
    - should not address items that are specified prescriptively in the RFP.
    - should not be included for items when exceeding the minimum specified performance will be of no advantage to the owner.
    - should not address items of such detail that conformance can be judged only by examination of the final design or analyses and shop drawings or construction submittals.
    - For evaluation proposer responsibility
    - Has the proposer fulfilled the requirements for participating in the procurement?
    - Will the proposer execute the contract responsibly, if awarded?
    - For evaluation of proposal responsiveness.
    - Develop evaluation statements for the evaluators that will draw their attention to the necessary details.
    - Should be developed concurrently with the design.
    - For the Quality Value Rating
    - A coarse scale of no more than five increments is recommended.
    - A point value scheme can be assigned to the different intervals for a quantitative analysis.
    - Evaluators must be able to clearly distinguish between any two categories to give meaningful assessments.
    - Ratings of poor and unacceptable are not necessary because proposals that do not meet minimum requirements should not be considered.
    - A numerical scheme is to be used as a point of discussion to clarify relative qualities and not as the actual evaluation exercise.

- **Methods of Evaluation**
    - Thomas, Kowadlo, Willenbrock, Hester, and Logan (1985)
- agency discretion
- bond requirement
- license requirement
- agency prequalification
- Birrell (1988) suggested the use of a modified bid in selecting a contractor. A contractor is rated after completing a project and the rating is used in future lettings. The evaluator rates the quality of the contractors performance by indicating one of five categories between poor and excellent for each listed criteria. The scores are then multiplied by assigned weights and the products are summed to produce a contractor's rating.
- Warwick (1992) – The essence of the proposed prequalification system was to have a on file an evaluated and acceptable copy of the contractor's quality manual.

- **Benefits/Advantages of Prequalification**
    - Lower (1982)
- Contractors benefit from a more level playing field
- Owners and designers benefit by avoiding the selection of unqualified contractors.
- Assurance of competent, successful parties
- Elimination of unqualified parties even though they can be bonded.

- Control over the number of bidders
- GC won't have to base their bid on questionable subs.
- The cost of bid solicitation is reduced
- Evaluation and award process is hastened by ascertaining responsibility in advance.
- It brings discipline and structure to the evaluation process.
- It protects the contractors from being awarded work they are incapable of doing.
    - Hauf (1976)
- Quality contractors will not be inhibited from submitting a bid because of the presence of unqualified bidders.
    - Eck and Karl (1995)
- The ability to react quickly in the case of urgent procurement.
- The internal cost of procurement is reduced.
- For suppliers
        - partnership
        - atmosphere of confidence
        - continuous orders
- For owners
        - low quality costs and problems
        - moderate prices
        - low risks
        - fast allocation
    - Nettleton (1948)
- Prequalification saves the unqualified bidder the time, money, effort, and embarrassment of not getting the project if they are low.
- It allows more ample time for investigation of contractors than does postqualification.
- It removes the low cost bias from the yes/no decision.
    - Russell (1996)
- For Owners …
        - It identifies constructors willing to submit a bid or proposal.
        - It provides an opportunity to screen out constructors who do not have sufficient qualifications and/or experience to execute a contract.
        - It reveals constructors who have a large backlog of current work that may reduce resources/capacity available for new projects.
        - It minimizes the probability of constructor default or delays.
        - It establishes organized, professional conduct as precedent for the climate of project's execution.
- For the contractor …
        - It assures contractors that bids will maintain a realistic relationship to sound engineering and construction practices and economic conditions. Thus, unqualified constructors are prevented form introducing uncertainty into bidding process.
        - It reduces the competition in the bidding process for a specific project.
        - It spares most bidders expense of preparing the estimate or proposal and embarrassment of disqualification.
        - It protects them from being awarded projects they are incapable of performing.
    - Rankin et al (1996) – Contractors who are allowed to bid will be qualified and hence the owner can concentrate on evaluating the bids rather than evaluating the contractors.

- **Disadvantages of Prequalification**
    - Lower (1982)
- Factual determination of responsibility is difficult
- Additional evaluation of responsibility is needed.
- Additional screening is a burden on the contractor.
    - Russell (1996)
- For the owner …

- Developing, implementing, and evaluating objective constructor prequalification criteria and evaluating constructors is costly.
- It is difficult to develop quantifiable criteria that are applicable for a given project circumstance that allows the owner to make accurate, sound, and consistent decisions.
- It is difficult to formalize the decision-developing process to make objective and sound decisions, without introducing subjective judgment and biases.
- There is a potential that qualified contractors will choose not to participate.
- High levels of competition may cause constructors to make bids at or near cost to keep organization viable. Thus, a reduced number of bidders and restricted competition can result in a higher project markup for the constructor. Therefore, the owner may incur a higher project cost, or perhaps simply a more realistic approximation of the final cost.

- For the contractor …
    - There is a potential for biased or erroneous denial of admission into bidding process.
    - There is an expenditure of resources required on the promotion and public relations to secure an opportunity to participate in the bidding process.
    - There is a limited growth potential as the result of diminished opportunity to expand into new areas in which the constructor does not have an established track record.

- **OT Summary – MCR**

Russell (1996) provided a brief summary of the prequalification programs implemented in state DOTs. Briefly, the prequalification process used is two fold. First a contractor must be identified as a qualified contractor in the prequalification process. Second a contractor is given a capacity factor. The maximum capacity rating (MCR) identifies the maximum dollar value of work a contractor can have on the books at any given time. This rating subsequently controls whether or not a contractor can bid or be awarded a specific project for which he is qualified. Work quality is incorporated into factors that are part of the applied equation.

- **Samples in addition to DOT – USPS and DB**
    - "Design-Build …" (1995) – The Design-Build Institute of America has a published guide for public owner to follow in making requests for qualifications or proposals. However, their method of prequalification is similar to most others in that while they pay lip service to prequalification for the purpose of increasing overall quality little is actually done in this area.
    - United States Postal Service (1995) – The USPS lends verbal support to assessing work quality in the qualification of contractors for their projects however they ascribe to the position that the criteria of evaluation is project dependent and therefore do not give a concrete formula for determining a contractor's rating based on quality.
- **Vendor Qualification/Certification Systems**
    - Several articles addressing vendor qualification/certification were considered. It was determined from them that the direction and focus of these type of systems is to effectively help a vendor/supplier improve the quality of its product by actively helping them improve their process or system or to eliminate all but one supplier for a given part.
    - Peddinti (1993) – Quantitative approaches for decision making in vendor evaluation.
- Linear weighting models – weight each criteria and sum the total
- mathematical/programming models – linear, mixed integer, and goal programming
- statistical/probabilistic approaches – cluster analysis
    - Peddinti (1993) – Classification of approaches to incorporate Q as a criterion for vendor evaluation
- weighting of Q characteristics
- cost analysis
- lot rejection analysis
- weighting method applied to a set of standards

- **Quality Evaluation of Designs**

- Napier and Freiburg (1990) – In their report, the authors discuss the evaluation and selection of proposals from designers. One portion of the selection process is the Quality Value Evaluation which is done for each proposal submitted. Criteria of evaluation are chosen based upon the conditions and priorities of the project. Major areas of the evaluation are proposer responsibility, proposal responsiveness, and proposal price.

- **Linear Models**
    - Russell and Ahmad (1990) – steps for contractor evaluation with a linear model
- identify criteria
- establish weights for each individual criteria
- establish decision rules
- rate alternatives for the individual criteria
- calculate aggregate weighted value
- rank-order values
- select alternatives
    - Russell and Ahmad (1990) – linear model features
- assumes independence among decision criteria
- easily understood and used by practitioners
- it is a systematic and structured approach
- relies on a decision maker to assign a rating based on the given data
- it does not account for imprecision and/or uncertainty in the data submitted by the contractor or in the owner's subjective evaluation.
    - Weighted
- Birrell (1988) suggests modifying a contractors bid with a factor derived from past performance evaluation reports and selecting a contractor on the basis of a modified bid. His system evaluates a contractor in one of five categories from terrible to excellent for each of the criteria listed. The following is a listing of the criteria proposed in the paper.
    - Overview of the contractor - 18%
        - contractor capability - 3%
        - overall performance - 7.5%
    - On site management - 22%
        - site staff management - 9.5%
        - craft supervision - 2.5%
        - interface with home office - 6%
        - quality of safety - 9%
    - Resource flows and productivity - 29%
        - labor and its use - 10%
        - equipment and its use - 8%
        - materials and their flow - 9%
    - Management of cost and time - 21%
        - cost management - 4.5%
        - time management - 12%
        - claims by and against the constructor - 3%
    - Interface of contractor with others - 10%
        - interface with owners and agents - 6.5%
        - interface with other contractors - 6%
        - interface with local construction industry - 0.5%
        - labor relations - 1%
        - interface with third parties - 2%
- Kumaraswamy (1996) described the system of prequalification in Hong Kong, the Housing Authority Performance Assessment Scoring System (PASS) in which weights are applied to different factors in the evaluation which are multiplied and summed to get a rating.
    - Utility Functions – Diekmann (1981) developed an application using a utility function as his model to compute a systematic contractor rating. He included in his paper a graphical description of his perception of a quality of product utility function.

$$EU(C_L) = \Sigma\int\pi_i u(x_i)f(x_i)dx$$

- Multiattribute utility theory – Holt, Olomolaive, and Harris (1994)

$$P1_j = Z1_j / Z1Max$$
$$Z1_j = \Sigma V_{ij} W_i$$
$$V_{ij} = Sv_{ij1} + Sv_{ij2} + \ldots + Sv_{ijn}$$

They also suggest an MFC to determine whether or not a contractor has s sufficient resource capacity.

$$MFC = M([CA - CL] + [0.5(NCA)] - NCL)$$

where M = modifying coefficient
CA = current assets
CL = current liabilities
NCA = noncurrent assets
NCL = noncurrent liabilities

- Pert – Russell and Ahmad (1990) – A model for prequalifying contractors is suggested in which three ratings are given to a contractor—optimistic, pessimistic, and average. This model is based upon the Pert approach to scheduling and the rating that precipitates out of the model is computed the same as an activity duration in Pert scheduling.
- P(failure) – Several authors which Russell (1996) summarizes present equations that predict the probability of a project/contractors failure. Each of them use different factors of business and/or the construction industry to predict the probability of success or failure on a project.

- Computer Programs
    - Qualifier 1
    - Qualifier 2

- **Owner Prequalification v. Bondability**
    - Russell (1990) – Surety bonds do not, in themselves, insure that a contractor is qualified to perform the contract.
    - Nettleton (1948) – A bond may protect against some financial losses but cannot predict delays and public inconveniences. Bonding company agents are not always the best evaluators of construction companies based on their past record of experiencing failure.
    - Thomas, Kowadlo, Willenbrock, Hester, and Logan (1985) – Although a project is bonded, the work is not guaranteed at the bid price. There will be further costs in incurred for rebidding the project, attorney fees, etc.

- **Prequalification v. Postqualification**
    - Rankin et al (1996) – A postqualification system requires less effort by the owners because they only qualify one or a few of the lowest bidders, whereas a prequalification system necessitates that all the prospective bidders be reviews. A potentially negative effect of postqualification is that contractors have invested time and effort in the bidding process.
    - Nettleton (1948) – Prequalification saves the unqualified bidder or contractor the time and money spent in making a bid and the embarrassment of a rejection if this bid should be the lowest. Prequalification is an aid to the awarding official, as the question of responsibility may be decided in a more just manner when there is ample time for consideration and investigation of contractors'' claims. The public official who awards the contract is relieved of considerable embarrassment and can simply award the contract to the low bidder who has already been qualified.
    - Perceived problems
    - Cost
- Administrative time
- Filing and Storage space

STATE-BY-STATE ACCOUNT

Alaska: Contractors are not required to prequalify for construction contracts (1990).

Alabama: The only "weighing scheme" is financial requirements.

§23-1-56. Same—Qualification of bidders

> "The highway director shall require shall require all bidders to furnish a statement … with respect to their financial resources, equipment, past record and experience…" Included shall be … "a listing of completed construction projects and bonding companies with whom business has been done for the past three years …"

The prequalification forms inquire about …

1. the number of years in business as a GC under the current name.
2. the number of years experience by the organization as a GC/sub and what kind of work was done.
3. major projects completed within the last three years with pertinent information.
4. projects under construction or in the process of being awarded.
5. construction experience of individuals in the organization.
6. banks with which the company has done business in the last three years.
7. vendors with whom a line of credit has been formed.
8. surety companies with whom business has been done in the last three years.

Arizona: The system primarily involves financial prequalification.

The prequalification forms inquire about …

1. the number of years in business as a GC under the current name.
2. the number of years experience by the organization as a GC/sub and what kind of work was done.
3. the applicant's commercial contractor license in the state.
4. previously being denied prequalification.
5. being removed from a bidders list.
6. failure to complete a project.
7. experience on projects with the department.
8. experience of principal individuals.
9. major projects completed as a GC/sub.

Arkansas: Prequalification required for GC's only.

The prequalification forms inquire about …

1. the number of years in business as a GC under the current name.
2. the number of years experience by the organization as a GC/sub and what kind of work was done.
3. failure to complete projects.
4. employee project failure.
5. construction experience of principal individuals.
6. projects completed in the last three years.
7. projects currently under way.

California: No Response.

Connecticut: Area of work specialty.

The prequalification forms inquire about …

1. the firm employees.
2. being debarred from bidding a project.
3. projects completed in the last five years by the firm with relevant info.
4. failure to complete awarded work.

5. employee failure to complete construction contract.
6. employment record of principal individuals.
7. in progress and not yet started work.

Colorado: The prequalification information “is reviewed for adequacy of personnel, equipment and past performance history.
No maximum volume of work is set through the prequalification process.
Inquiries about …
1. business partners and associates in the last 5 years.
2. how many years the company has been in contracting/GC/sub.
3. principal individual’s experience.
4. company projects completed in the last 5 years.
5. being denied prequalification.
6. failing to complete an awarded contract.
7. indictment/conviction of bid/contract violations.
8. construction type.

The code of regulations identifies criteria of past performance on highway contracts including, but not limited to, compliance with all contract terms and specifications, satisfactory quality of workmanship*, and consistent on-time performance.

*The packet of information gives no indication on how the quality of the contractor’s work will be assessed.

Florida: The prequalification forms inquire about …
1. the number of years in business as a GC under the current name.
2. the number of years experience by the organization as a GC/sub and what kind of work was done.
3. officers and directors of the organization.
4. indictment or conviction of any company officials.
5. debarment or suspension from bidding.
6. contracts and subcontracts completed in the last 3 years.
7. experience of principal construction supervisory personnel.
8. failure to complete awarded work.
9. failure to complete a construction contract.
10. bankruptcy.
11. status of contracts on hand.
12. class/specialty of work to be done.
13. states in which you are qualified.

§14-22.003(1)(a)3 The Department will evaluate statements regarding … satisfactory work performance record, including but not limited to, history of payment of liquidated damages, untimely completion of projects where liquidated damages were not paid, cooperative attitudes, and defaults by the applicant.

The above information must be acquired by contacting the owners of previous projects completed by the contractor using the previous project list.

The following is used in developing a capacity rating for the contractor…’

One of the items in the evaluation is Past Performance Reports on work completed for the department in the last 5 years. Past performance reports reflect the applicant’s organization, management, and work performance…

Effectiveness of supervision in … providing quality control.

There is a complete section on work effort and product quality control.

1. Quality of work completed.
2. Allowance of sufficient time for job site sampling and testing of materials before proceeding with the work.
3. Effort to provide and maintain adequate survey station markers and grades.
4. Pre-planning on complicated work to assure a smooth operation.
5. Quality of the work with normal inspection.

An extensive assessment of the contractors performance on the project is included.

Georgia: A past performance report is completed at the end of a project by the District Engineer or by the previous owners if previous work has not been done for the department. These reports are the basis for the past performance rating used to compute the contractor's ability and performance rating.

Work classification and specialties are requested.

Inquiries about…

1. the amount of time the company has been in business under its current name.
2. years of experience as a GC/sub.
3. construction experience of principal individuals.
4. failure to complete awarded work.
5. individual's failure to complete a contract.
6. work performed in the past 3 years.

Idaho: No prequalification procedure is used. The only requirement for bidding is a contracting license from the Public Works Contractors Licensing Board and the ability to post bond.

Illinois: Inquiries about…

1. the amount of time the company has been in business under its current name.
2. years of experience as a GC/sub.
3. type of work in which you have experience.
4. failure to complete work.
5. material vendors with whom you deal.
6. construction experience of principal individuals.
7. bankruptcy.
8. parent company.

A work rating is calculated to indicate the dollar value of work a contractor can perform within a particular season. The work rating is based on 3 factors—performance factor, experience factor, and equipment factor. " The performance factors are based on an evaluation of quality of work, ….. The rating is on a scale of from 1 to 4" with 1 being unacceptable and 4 being excellent. This rating is given to each contractor by the District Engineer in consultation with the District Bureau of Construction at the end of each construction season.

The experience factor is the dollar value of pertinent work completed by the contractor. The equipment factor is a measure of the contractor's physical capacity to do work.

Missouri: Any contractor can be a successful bidder if he can obtain the necessary bond and insurance and has completed the required questionnaire within 10 days prior to bid opening.

Contractors are evaluated each year with regard to their contract administration and a rating is determined. A contractor with poor performance is further evaluated for a period of disqualification.

The questionnaire inquires about …
1. years of experience as a GC/sub.
2. contracts completed within the last three years.
3. construction experience of major owners.
4. debarred from or restricted bidding privileges.

Iowa: Letters of contractor performance are kept on file and reviewed for prequalification.

The questionnaire inquires about …
1. type of work done.
2. years of experience under current name.
3. name change.
4. years of experience as GC/sub.
5. failure to complete awarded work.
6. construction experience of principal employees.
7. past projects completed.
8. bonds furnished and bonding companies.

Must be prequalified for projects in excess of $100,000.

Indiana: Inquiries about …
1. type of work and years of experience in it.
2. years experience under current name.
3. years experience as GC/sub.
4. projects under contract or pending.
5. construction experience of principal individuals.
6. who work was done for.
7. prequalification for other owners.
8. failure to complete awarded work.

Kansas: Inquiries about …
1. type of work and years of experience.
2. years of experience under current name.
3. years of experience as GC/sub.
4. failure to complete awarded work.
5. prequalification denial.
6. removal from bidders list.
7. projects completed in the last two years or in progress.
8. construction experience of principal employees.
9. qualification in other states.

Prequalification of Contractors

8.3.1 For a General Financial Rating a factor having a range from 1 to 20 will be assigned each contractor qualifying in Kansas. This factor will be based on the performance record of the contractor in the highway construction field. Quality of work, prompt completion, prompt payment of accounts, attitude toward the Kansas DOT and attitude toward the public will be determining factors…

8.3.2 Information used for the rating will be supplied from available records of the Secretary of the DOT, reports by the Bureau of Construction and Maintenance, and the Contractor's Qualification Statement and Experience Questionnaire.

Kentucky: Inquiries about …
1. type of work.
2. major projects other than with Kentucky DOT.
3. qualification in other states.
4. construction experience of principal individuals.

5. all major contracts awarded in the last 3 years.
6. certificates of eligibility or licenses issued by other states or agencies.

Maine: Inquiries about …
1. years of experience under the current name.
2. years of experience in highway or highway related work.
3. the last 6 contracts completed.
4. current contracts.
5. failure to complete awarded work.
6. construction experience of principal individuals.
7. referrals.

There is no formal qualification however the DOT does contact the references of a new contractor.

Maryland: Contractors must be registered with the State Department of Assessment and Taxation and possess a valid Maryland Construction License. If they are the apparent low bidder, they must complete an Experience/Equipment Certification within 10 days.

Inquiries about …
1. years experience as GC/sub in type of work.
2. construction experience of principal employees.
3. special qualifications of firm members.
4. principal projects completed.
5. who work has been done for and references.
6. failure to complete awarded work.
7. work presently under contract or pending.

A Report of Unsatisfactory Contractor Performance/Progress can be filed by appropriate personnel. In it there is a section that includes workmanship, compliance with specs, and others.

Massachusetts: A report card system is made out by resident engineers which can be used to reduce the capacity multiplier.

Inquiries about …
1. years of experience under the current name.
2. years of experience as a GC/sub.
3. major projects completed in the last 5 years.
4. failure to complete awarded work.
5. completion of last 3 contracts on time.
6. construction experience of principal employees.
7. type of work.

Minnesota: The only requirement is that the contractor be able to post a performance bond.

Mississippi: The only requirement for bidding is that a bid bond is posted and if the contractor is low bidder a payment and performance bond must be posted.

Montana: Contractors must only be able to post bond.

Nebraska: Quality of work holds 20% of the weight in calculating the earned premium rating.

Quality of work is given points based on ratings of superior, excellent, good, fair, poor, and unsatisfactory.

Inquiries about …
1. type of work.

2. years under current name.
3. previous name.
4. amount of work to sub.
5. authorized for business in other states.
6. other state highway dept. worked for.
7. largest contract ever completed.
8. failure to complete awarded work.
9. prequalification denial or removal from bidders list.
10. surety losses.

Nevada: NDOT uses past performance ratings for the last 4 years, past performance ratings for the current year, and average past performance rating for the past 5 years. The average past performance rating for the past 5 years is based on the resident engineer, district engineer, and contract compliance officer.

Past performance reports include quality of work and others.

Inquiries about…
1. years under current name.
2. types of work.
3. years experience as a GC/sub.
4. projects completed in the last 5 years.
5. failure to complete awarded work.
6. construction experience of principal individuals.

New Hampshire: Inquiries about…
1. type of work.
2. years under the current name.
3. years experience as a GC/sub.
4. failure to complete awarded work.
5. conviction of anti-trust violation.
6. debarred from performing work on a contract.
7. projects currently under way.
8. projects completed in the last 3 years.
9. construction experience of principal employees.

New York: NY DOT does not prequalify, they postqualify.

Inquiries about…
1. years in the business.
2. years under current name.
3. previous names and time.
4. personnel employed.
5. failure to complete awarded projects
6. 10 most recently completed projects.
7. 10 most recently completed subcontracts.
8. Status of uncompleted public works contracts.
9. stop work notices, liquidated damages, liens, or claims.
10. criminal conviction.
11. denial or revocation of prequalification.

North Carolina: Inquiries about…
1. years under current name.
2. significant projects completed.
3. significant incomplete projects.
4. debarred from bidding or performing public work.

5. bankruptcy.
6. references.
7. type of work.
8. construction experience of principal employees.

North Dakota: Inquiries about…
1. licensing.
2. years experience as GC/sub.
3. barred from bidding public projects.
4. failure to complete awarded work.
5. construction experience principal employees.
6. principal projects completed in the last 5 years.
7. construction projects currently underway.
8. type of work.

Ohio: Ohio DOT qualification is partially dependent on responsibility and competency which is partially based on performance which includes quality of work. This information is from Bureau of Construction reports or other accredited agencies.

Inquiries about…
1. type of work.
2. key construction personnel and experience.
3. largest contracts awarded in the last year.
4. important projects completed prior to the last year.
5. vendors over the last 2 years.
6. business failures.
7. compromise with creditors.
8. failure to complete contract.
9. liens against work.
10. failure to qualify for a bond.
11. payment controversy.
12. judgments, suits, or claims pending.

Oklahoma: Contractors can be disqualified when 30% or more of the time is used and exceeds the amount of work done by 15%.

Inquiries about…
1. years of experience under the current name.
2. years of experience with ODOT as GC/sub.
3. current or past projects in Oklahoma in the past 5 years.
4. current or past projects other than those in Oklahoma in the past 5 years.
5. failure to complete awarded contracts.
6. litigation with creditor, surety, or bank.
7. performing work under DOT QC/end result specs.
8. bankruptcy.
9. construction experience of principal individuals.
10. vendors in the past 3 years.
11. type of work.

Oregon: Inquires about…
1. type of work, value, states, and yrs experience.
2. projects undertaken in the last 5 years.
3. years experience under the present name.
4. years experience as a GC/sub.
5. construction experience of principal employees.

6. license.

Pennsylvania: Inquiries about…
1. work type.
2. prequalification and capacity rating in other states.
3. years under the current business name.
4. years experience in highway construction.
5. construction experience of principal employees.
6. failure to complete awarded work.
7. different types of work completed or in progress over the last 5 years and pertinent info.
8. convictions of principal employees.

Past performance reports done by the dept. on previous projects done by the contractor and reports done by outside entities will also affect the qualification of the contractor.

Rhode Island: No formal prequalification system.

Inquiries about …
1. qualifications of supervisory personnel.
2. experience records.
3. bondability.

Utah: Prequalification for projects > $500,000.

Ratings based on experience, past performance, and financial analysis.

Use a Contract Performance Report produced by the resident/project engineer.

The Contract Performance Report inquires about…
1. effectiveness of mgmt support of contract supervision.
2. effectiveness of on-site supervision.
3. cooperation in negotiation of modifications and disputes.
4. demonstration of interest in achieving desired level of construction.
5. cooperation with inspectors.
6. timely commencement of work.
7. prosecution of the work.
8. adequate personnel.
9. prompt payment.
10. legal compliance. (EEO, safety, labor)
11. cooperation with utility companies.
12. prompt furnishing of documentation and reports.
13. final clean-up.

Questionnaire inquires about…
1. years under the current name.
2. years experience as GC/sub.
3. projects in the last 3 years.
4. failure to complete awarded work.
5. referrals.
6. construction experience of principal employees.

Vermont: Prequalification requires a review of finances, personnel, equipment, and work history. Unsatisfactory performance judged by workmanship and/or progress is basis for denial or reduction of prequalification.

Questionnaire inquires about…

1. years under current and other name.
2. years experience as GC/sub.
3. criminal or civil convictions.
4. failure to complete awarded work.
5. vendors over last 3 years.
6. major projects completed over the last 5 years.
7. construction experience of principal employees.
8. prequalification and ratings in others states.
9. type of work.

Virginia: District Engineers submit performance reports on contractors working in their district. Unsatisfactory performance is grounds for disqualification.

Questionnaire inquiries about…
1. type of work.
2. prequalification, work classification, and rating in other states.
3. years under the current name.
4. years experience in each type of work.
5. experience of principal employees.
6. failure to complete awarded work.
7. removal from bidders list.
8. work completed in the last 5 years.
9. vendors over the last 3 years.

Washington: Written inquiries are made to previous owners.

To obtain a proposal form, a contractor must have "a satisfactory record of performance, integrity, judgment, and skills" among other things.

Questionnaire inquires about…
1. years under current name.
2. years experience as GC/sub.
3. projects currently underway.
4. projects completed in the last 3 years.
5. failure to complete awarded work.
6. construction experience of principal employees.
7. type of work.

Wisconsin: A "working factor" is used that is based on DOT experience with the contractor.

Questionnaire inquires about…
1. years under current name.
2. years experience as GC/sub.
3. failure to complete awarded work.
4. construction experience of principal individuals.
5. references.
6. projects completed in the last 3 or more years.
7. types of work.
8. qualification and rating in other states.

Wyoming: "The applicant's previous and present job performance will be evaluated."

Contractor may be disqualified for demonstrating an inability to meet contract requirements.

Questionnaire inquires about…
1. type of work.

2. years under current name.
3. years experience as GC/sub.
4. projects currently under way.
5. projects completed in the last 3 years.
6. failure of awarded work.
7. construction experience of principal employees.

Texas: Inquires only about debarment from bidding. No real quality questions.

South Dakota: Prequalification required on bids > $100,000

"The past experience of the contractor (quality of work, timeliness, etc.) with the DOT on projects can also influence limitations placed on the contractor's prequalification on future projects.

Maximum capacity rating can depend on experience of personnel, previous record, and others.

Deductions to the current rating may be made because of "quality of work performed on previous contracts."

Questionnaire inquires about…
1. years under current name.
2. years of highway work as GC/sub.
3. failure to complete awarded work.
4. bid rigging charges.
5. references.
6. projects completed in the last 2 years.
7. construction experience of principal individuals.
8. type of work.

South Carolina: Questionnaire inquires about…
1. years experience under the current name.
2. years experience as GC/sub.
3. construction projects currently underway.
4. projects completed in the last 3 years.
5. failure to complete awarded work.
6. construction experience of principal individuals.
7. references.

Qualified contractors will be rated partially on the quality of work.

New Jersey: Inquires about…
1. projects completed in the last 3 years including extensions, penalties, and claims.
2. years under the current name.
3. years experience as a GC/sub.
4. construction experience of principal individuals.
5. failure to complete awarded work.
6. suspension or debarment.

An "efficiency factor" is calculated based on the NJDOT Contractor's Performance Report or inquiries to owners for whom the applicant worked.

A "quality point factor" is derived from the quality level or work performance provided by the responses to the NJDOT Inquiry of owners.

The Contractor's Performance Report assesses…
1. compliance with direction by Resident Engineer.

2. compliance with Traffic Control Plan.
3. performed work in accordance with plans and specs.
4. compliance with interim and final completion dates.
5. adequate equipment available.
6. adequate staffing.

Michigan: Key personnel performance.

Quality of work may cause a reduction in rating.

Statement of current contracts and subcontracts.

Questionnaire inquires about…
1. years under current name.
2. years experience as a GC/sub.
3. contracts completed or awarded in the past 2 years.
4. prequalification and rating in other states.
5. failure to complete awarded work.

ANNOTATED BIBLIOGRAPHY

1) American Society of Quality Control (ASQC) 49th Annual Quality Congress Proceedings

- Suppliers base; customer satisfaction elements; how a medium - size manufacturer is creating a suppliers base. (p. 816)

- Suggested program summary:

    1. Definition and Implementation of Supplies Management System
    2. Procurement / Applications Engineering
    3. Ship-to-Stock Program
    4. Closed - Loop Corrective Action / Problem Solving System
    5. New Products Characterization, Requirements, Suppliers' Capabilities
    6. Inventory Management for Bill of Materials Items

- The above process is used to develop a list of preferred and approved suppliers.

- A Cross - Functional Approach to Supplier Evaluation (p. 825), **Spooner & Collins**

- A cross-functional team was used to develop a supplier rating system based on quality and others.

- Quality was evaluated based on quality system evaluation and ongoing quality performance

- Quality composed 35% of the overall rating.

- Quality performance is measured by the material rejection report.

- The material rejection reporting system includes…

    1. % of suspect parts (PPM) (# rejected/ #received) * 1,000,000
    2. % of incidence (# complaints / #of shipments) X 100
    3. Response rating – subjective rating of suppliers response to concerns
    4. Severity rating – severity of problem

- Suppliers are given 1 of 5 status based on quarterly evaluation

2) ASQC 47th Annual Quarterly Congress Proceedings

- "Health Care Quality - Based Contracting," **Collier and McAdams**

- Data is collected into categories and compiled quarterly. (Columbus model)

- Data is presented to the public and the better hospital should get more business (Cleveland)

3) ASQC 46th Annual Quarterly Congress Proceedings

- "Most Vendor Certification Methods are Trivial" (p. 230), **Bhote**

- Active concrete help for suppliers.

- Transfer supplier relationships to win-win from win-lose.

- Develop a management steering committee.
- Develop commodity teams.
- Measure problems by PPM.
- Use QFD to develop specifications.
- Important characteristics are clearly identified and communicated.
- Important process parameters are clearly identified and communicated
- Value Engineering
- Integration of quality, cost, delivery, and effectiveness.
- "Supplier Development for the 21st Century." (p. 649), **Gould**.
- Steps: select, qualify, measure, and improve (standardized)
- Classify suppliers
- Classify components

4) ASQC 45th Annual Quality Congress Proceedings

- Supplier Qualification – Variations for Excellence (p. 185)
- Classical process:

    1. New Supplier – Can the supplier provide the product quality needed?
    2. Old Supplier – Can this operation continue to provide the necessary product quality?

- Aerospace & Defense, Pharmaceutical, Energy, Service Products & Commercial Product
- Pharmaceuticals – CGMP (Current Good Manufacturing Practices)
- Energy – 1 Rating System proposed (experience) – final criteria is cost (see p. 194)
- Weighing criteria is dependent upon item and needs of project
- Service Products – Rate quality of both service & product.
- Major rating categories:

    1. delivery
    2. pricing
    3. customer service
    4. product quality

These categories can receive ratings of excellent, acceptable, marginal, or unacceptable.

- Commercial Products – Qualification is based on performance measures and an evaluation of the majority of the quality system.

{This paper addresses the qualification systems in general. Very little is said about how quality is actually assessed.}

- "Survival with Supplier Management." (p. 902), **Martin**

- Program goals:

    1. Improve working relationships
    2. Improve overall product quality
    3. Reduce lead times
    4. Reduce costs
    5. Improve delivery performance

- Categories of measurements:

    1. Delivery performance
    2. Price and value analysis
    3. Service and technical support
    4. Quality systems

- Quality Systems Measurement

    1. Self-evaluation questionnaire and on-site audit.

    Quality Manual content vs. actual practice.

    Components:

        a. Facilities Information Questionnaire – organization size, product lines, capabilities, key personnel
        b. Quality Evaluation Questionnaire –quality systems / procedures

    2. The In - house Format

        Areas for Measurements

        a. Receiving Inspection – can be eliminated once supplier is certified
        b. Discrepancy Reporting – reports on problems of parts
        c. Internal Supplier Warranty Rework Reports – reports of rework on suppliers' parts

    3. Field Warranty Performance

        a. Field Replacement Parts Test –parts sent out to replace those under warranty.
        b. Warranty Labor – cost of work performed on a defective part.

    4. SFC commitment of usage – statistics are useful for developing prevention and audit systems in place of detection systems.

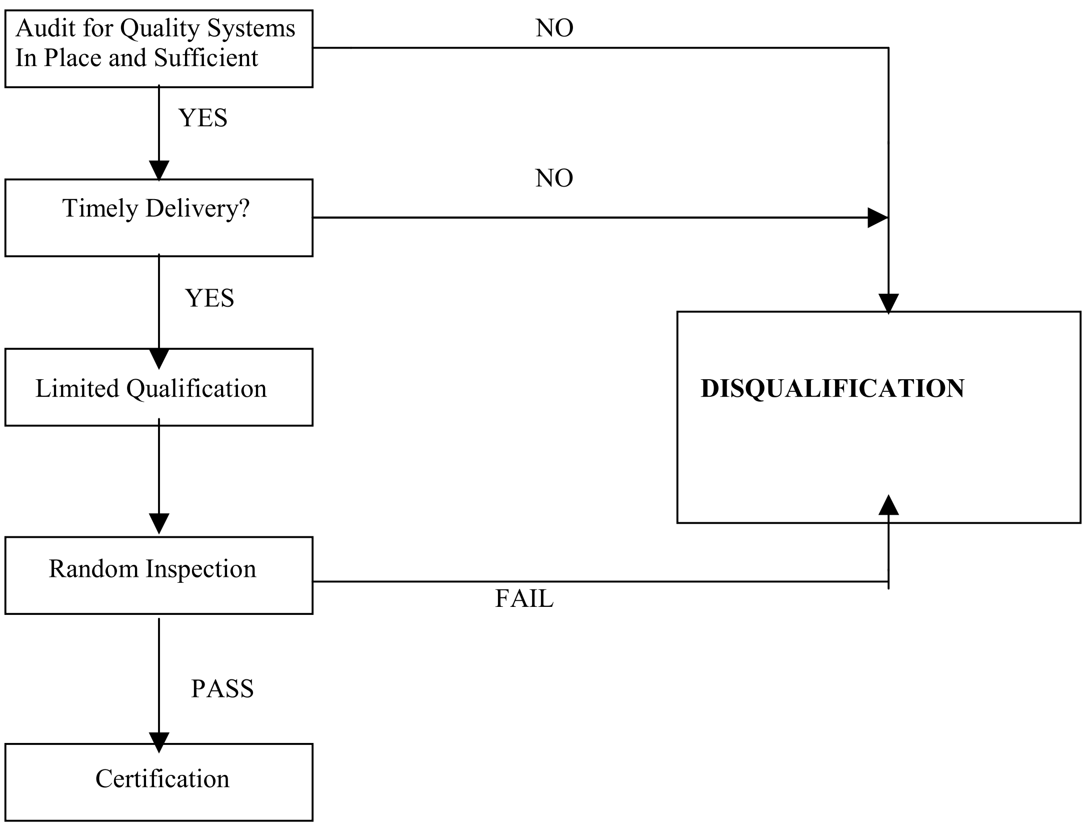
Score levels are set for qualification status

It seems like manufacturing companies make the assumption in their evaluation process that the existence of quality systems produces quality products.

5) ASQC 42nd Annual Quarterly Congress Proceedings

"Evaluating Suppliers Utilizing Perceptual Mapping" **Roth**

This paper presents a way to visually map a supplier evaluation based on quality performance and delivery, which compose the two axes. An evaluation is plotted on a graph and the supplier is rated depending what area of the graph the point falls in.



It seems like the manufacturing industry is more interested in developing quality suppliers than just rating them as pass/fail. Their long-term relationship with suppliers makes this approach logical whereas construction in most cases is "one and done." A significant part of their rating/status is based on their ability to perform at the desired level. If suppliers' wares are not up to specifications a buyer will make an effort to form an unofficial partnership with a supplier. The goal in several references was to minimize the number of suppliers to a few with exceptional ratings. By minimizing the number of suppliers, the buyer must communicate with fewer firms, which should be more effective. Effective communication should help develop a strong relationship, which may help quality improvement efforts. It is interesting that this is contrary to good organization theory, which states that the principal firm should not allow suppliers to have power over their operation. By limiting the number of suppliers, the buyer is giving them power over him.

The manufacturing industry does not have a binary quality assessment system. Literature seems to suggest that, in general, the system is binary (yes/no). However, the "yes" category in further subdivided. Some suppliers depending on their rating are given limited certification versus others getting an unlimited certification. With time and appropriate performance, limited can be upgraded to unlimited. The unlimited status may include removal of the inspection request. Status may be reviewed at designated intervals.

6) "Most Vender Certification Methods are Trivial," Kiki Bhoti

- See Table 1 for a tabular summary of certification methods existing vs. suggested by Bhote.
- Management Style: Dictatorial / Remote Control vs. Active Concrete Help.

  Dictatorial – bully supplier when problems arise and possibly dump them.

  Remote control – no interaction, poor communications.

  Active concrete help – supplier is coached along.

- Partnership/Trust: Confrontational Relationship vs. Partnership
- Management Steering Committee: Non - existent vs. Key Corporate Structure.
- Commodity Teams: Void vs. WorkHorse of Supply Management.
- Measurement: AQL vs. PPM - Switch from control charts
- Specifications: Arbitrary/Vague vs. Realistic through DOE: boilerplate vs. QFD
- Classification of Characteristics: Unknown vs. Highlights. Some reports are more important than others.
- Process Characterization/Optimization: Inadequate Process Capability Studies vs. DOE
- Positrol & Process Certifications: Unknown vs. Powerful Tool. Positrol identifies important parameters and determines measurement and control strategies.
- Reliability: Paper Studies vs. Multiple Environment over Stress Test – quality vs. quantity time & stress
- Value Engineering: Ignorance vs. A Tool for Quality/ Cost Improvement. Value engineering is good for cost reduction, quality improvement and customer satisfaction
- Cost Targeting / Early Supplier Involvement: Way Out vs. Way of Life
- Financial Incentives / Penalties & Foreign Concept vs. Business Practice
- Cycle Time Management: Off-the-Screen vs. JIT

7) "Cost – Plus Contractor Selection: A Case Study," Diekmann

- Multi - dimensional utility approach

- Owners want to minimize project cost but also require contractors to maintain schedules, be quality oriented, safety minded, etc.

- A utility function is a device, which quantifies the preferences of a decision-maker by assigning a numerical index to varying levels of satisfaction of an objective.

$U(X) = \Pi_1 U(X_1) + \Pi_2\ U\ (X_2) + \ldots.. + \Pi_I\ U(X_I) + \ldots + \Pi n\ U(X_n)$

This model requires independence of the utility functions involved.

- 4 High - Level Objectives:

1. Cost exposure
2. Company stability
3. Quality of product
4. Management capability

- Measured by quality of technical services provided & the Quality Control / Quality Assurance services.

- Sec quality evaluation structure on p. 20

- The decision-maker must:

1. Assign values to (Π_I) – the sealing function.
2. Describe v(Xi) – determine to what degree various levels of performance satisfy his preferences and to what degree those preferences are modified in the presence of uncertain performance.
3. Describe f (Xi) – the probability density function. Assign a range of potential performance for each performance criterion for each contractor.

8) "Prequalification and C-competitiveness," Drew and Skitmore

- Select contractors who…

1. are prepared to undertake and complete the work at a competitive price.
2. complete the work on time.
3. construct the work to the required quality standards.
4. execute the work without a significant risk of extra financial burden on the client.

- This paper approaches prequalification based on previous price levels in competition.

- Through prequalification, the owner wants to select good competitors & eliminate bad ones.

- The objective of prequalification is obtaining the lowest bid at the minimum bidding cost.

- Prequalification should be measuring competitiveness.

- A measure of competitiveness is each bid's % above the winner.

This paper is only based on the bid number comparison and its consistency or lack thereof. Quality is not a point of discussion.

9) "Supplier Development for the 21st Century," Richard Gould

- Supplier development is affected by…

  1. competition.
  2. technology evolution.
  3. time to market.

- Key to successful supplier development – Plan-Do-Check-Act. Which in supplier terms is Select – Qualify – Measure – Improve.

- Selection – Marketing must accurately define the product.

- Design Engineering must establishes roles, select components, recommend qualified suppliers, and provide quality requirements.

- Component Engineering must select suppliers, prepare and release component specifications

- Supplier Quality Engineering must recommend suppliers with qualified quality systems.

- Materials must select low - cost supplier from qualified list.

- Qualification - Supplier Quality Engineering audits supplier quality system for approval and ensures quality products are being produced.

  - Supplier Quality Engineering and the qualification must evaluate supplier manufacturing process, capabilities and stability

  - Component Engineering and the Qualification Lab evaluate product against specifications.

- Measurement – supplier regularly provides process and product data.

Improvement – Supplier pursues defect-free process and product.

Classify suppliers as 1. Preferred, 2. Approved, 3. Specialist.

Classify components as 1. Critical 2. Commodity 3. Market-sensitive

10) "System of Prequalification and Suppliers Rating of Deutsche Telekom AG under EC-Law," Jurgon Eck & Arno Karl

Advantages

- Fast reaction in case of urgent procurement.
- Reduction of internal cost of procurement.

Qualification based on…

1. Evaluation of a form

2. Audit of

- Quality management system
- Development & production process
- Products

3. Former experience with supplier as

- Reliability
- Service
- On - time delivery

Advantages to Suppliers

- Partnership
- Atmosphere of confidence
- Continuous orders

Owner Advantages

- Low quality costs
- Low risks
- Fast allocation

11) "Constructing The Team: Final Report of the Government/Industry Review of Procurement and Contractual Arrangements in the UK Construction Industry," Sir Michael Latham

- Qualification – means a contractor getting on to an approved list
  Prequalification – drawing up a list of firms which are suitable for a particular project.

- Prequalification by different agencies should be combined into a single program.
  Duplication of work adds to owner expense.

- A single prequalification database maintained by a public agency and accessible by private owners is proposed.

- It is intended that the evaluation process will help increase the value/$ of projects built.

- Auditors must be accepting of the fact that the lowest price may not indicate the chosen alternative

12) "Prequalifying Construction Contractors," Jay R. Lower

- With the possible exception of the marginal or unqualified contractor, prequalification is advantageous to all concerned.

- Construction benefit – assurance of more level playing field.

- Owner / Design Professional benefit – avoid selecting unqualified contractor.

- If prequalification is not done prior to bidding, the contractor runs the risk of spending money on bidding and then being embarrassed by being disqualified and the owner runs the risk of accepting an unqualified contractor.

- Prequalification bidder lists should be updated regularly.

- Prequalification bidder lists should categorize bidders for types of work.

Advantages of Prequalification

- Assurance of competent successful parties.
- Elimination of unqualified parties even though they can be bonded.
- Control over # of bidders.
- General Contractor (GC) won't have to base their bid on questionable subcontractors.
- Reduced cost of soliciting bid
- Hastens evaluation – award process by ascertaining responsibility in advance
- Brings disciplined structure to contractor evaluation process.
- Protects contractors from being awarded work they are incapable of doing.

Disadvantages of Prequalification

- Difficulty of factual determination of responsibility.
- Need for additional evaluation of responsibility.
- Burden on contractor for additional screening.

13) "Building Contracts for Design / Construction 2nd Edition," Hauf

- An inherent premise of competitive bidding is that the finished building will be substantially the same quality if constructed by any one of the bidders.

- The lack of a prequalification process may inhibit quality contractors from spending the resources to submit a good proposal because they feel less qualified firms will do it for less money. Thus we have complimentary or courtesy bids.

- The purpose of prequalification is the elimination of incompetent, overextended, and under - financed contractors

- Default on a previous contract presents the strongest argument for disqualification.

- The weakness of current prequalification methods is the lack of effective means for evaluating intangible factors such as quality, technological know-how / efficiency.

14) "A Review of Contractor Selection Practice in the UK Construction Industry," Holt, Olomolaiye, Harris (pp. 210-345)

- A paradigm shift in attitudes is required of selection practitioners. Emphasis presently directed towards encouraging lowest bid should be redirected towards establishing contractor ability for achieving client satisfaction (project performance, quality of completed project, etc.).
- The underlying principle should be best value for the client's money.
- All selections should pivot on time, cost, and quality.
- An assumption that once contractors are prequalified low bid should be accepted is erroneous.
- A better option would be to integrate prequalification as part of every selection process, performed just prior to invitation to tender.
- Low quality performance & product are risks taken.
- Any alternative selection proposal should be objective but unfortunately absolute quantitative analysis is not entirely possible.

15) "Evaluating Prequalification Criteria in Contractor Selection," Holt, Olomolaive, & Harris

- Prequalification Factors…

  1. Contractor's Organization
  2. Financial Considerations
  3. Management Resource
  4. Past Experience
  5. Past Performance

- Each factor has associated subvariables

$Zl_I = \Sigma\ Vi_I\ W_I$ where Zl_I = score of contractor I
Vi_I = variable I for contractor I
W_L= weight of variable I

- Factor Selection and weighting criteria is based on surveys
- Age of the company may be correlated with product quality
  - Membership in associations indicates image and reputation
- QC policy assessed by QA audit, client input, independent evaluation and registration
- Health and Safety Policy is evaluated
- Site management is crucial to project success.
- 4 Key Qualifications are:

1. Academic qualifications

Memberships in professional associations
3. Age range of the company
4. Overseas experience of the company

- Key Personnel - Years with Company: Individuals who have worked up through a single organization will be better.
- A Continuing Education program on management techniques is a plus.
- Geographic Experience : In a new area, companies will have a difficult time acquiring quality suppliers and labor.
- Time and Cost overruns may be valid.
- Quality Achieved: past clients' level of satisfaction with quality (based on 1-10)

16) "Contractor Evaluation & Selection: A Hong Kong Perspective," Mohan M. Kumaraswamy

- Building & Environment 31 (3) pp. 273-282 1996
- The Construction Quality Assessment System (CONQUAS)
- Quality is assessed in the PASS program for Hong Kong
- The article does not say a whole lot about quality. It has some interesting references.
- Includes a summary of work done in other countries.

17) "Recent Experiences in Prequalifying Bidders for Construction Projects," E T Nettleton

- Business failures are caused mostly by:

  1. Faulty bidding
  2. Unforeseen conditions
  3. Insufficient financing
  4. Lack of experience can be minimized through prequalification.

- Prequalification – the determination of the responsibility of each contractor to satisfactorily undertake and complete a certain construction project before the issuing of plans, specifications, and proposals.
- Prequalification is an extension of the principle applied to the professions of law, medicine and engineering in which persons must have a certain understanding of appropriate theory and applicable experience to be licensed for business.
- Good contractors who understand the industry, projects, and their own abilities can effectively prequalify themselves.
- The chief cause of over - shooting financial abilities is a desire for quick growth.
- A bank may protect against some financial losses but cannot predict delays and public inconveniences.

- In reality, owners pay for the bonding anyway.

- Low bidding by unqualified contractors will drive qualified contractors out of business because they can't compete.

- Bonding company agents are not always the best evaluators of construction companies based on their past record of experiencing failure.

- Prequalification saves the unqualified bidder the time, money, effort, and embarrassment of not getting the project.

- Prequalification allows more ample time for investigation of contractors.

- Prequalification removes the low - cost bias from the yes/no decision.

"As Mark Twain would say, everybody talks about the weather but nobody does anything about it. "

- Reasons for not Prequalifying

    1. Hope that a qualified bidder will be low so a decision of qualification does not have to be made.
    2. Add competition and drive down the qualified bid.

- Objections to Prequalification

    1. Prequalification shuts out the new contractor.
    2. Prequalification would reduce competition.
    3. Favoritism
    4. Invasion of private affairs by questioning

- Responsible Bidder – one that is able to prove that he is possessed at the specified time of satisfactory skill and knowledge, good integrity, sufficient plant, equipment, personnel, labor and finances to undertake and satisfactorily perform the construction work upon which he wishes to bid. He must also be able to acquire the necessary materials.

- Responsibility should be determined by annual filing of a statement and supplementary info from time to time.

- The financial ability of the contractor is a black box and may be assessed in many ways depending upon how the statement is interpreted.

- Common sense is a valuable asset in evaluating contractors.

18) ""PERT" Approach to Contractor Prequalification Analysis," Jeffrey S. Russell & Irrtishad Ahmad.

- Steps for contractor evaluation with a linear model.

    1. Identify criteria
    2. Establish weights for each individual criteria
    3. Establish decision roles.
    4. Rate alternatives for the individual criteria
    5. Calculate the aggregate weighted value.
    6. Rank - order values
    7. Select alternatives

- Linear model features…

    1. Assumes independence among decision criteria
    2. Easily understood and used by practitioners
    3. It is a systematic and structured approach
    4. Relies on a decision-maker to assign a rating based on the given data.
    5. It does not account for imprecision and/or uncertainty in the data submitted by the contractor or with the owner's subjective evaluation.

- Suggested model features

    1. Multiple ratings for a single criterion are possible

- Basic model assumptions

    1. The ratings on each criterion for each contractor are random variables implying random distribution.
    2. Distributions can be converted to a common continuous probability distribution.
    3. The weighted sum of the mean is the mean of the aggregate ratings described by a normal distribution whose standard deviation is the square root of the sum of the variances of all the criteria for each contractor.

19) "Surety Bonding and Owner-Contractor Prequalification: Comparison," Jeffrey S. Russell

- Awarding authorities should verify that the bidder has adequate financial resources or the ability to secure them.

- Has the necessary experience, organization, and technical qualification: available personnel resources and has or can acquire the necessary equipment to perform the proposed contract.
- Is able to comply with the required performance schedule or completion date, taking into account all existing commitments.
- Has a satisfactory record of performance, integrity, judgement, and skills.

- Surety bonds do not, in themselves, ensure that a contractor is qualified to perform the contract.

- Prequalification can ensure that contractor capabilities and characteristics match the requirements of the project. To be successful, prequalification procedures must be rational, understandable, visible, defendable, documented, and not unfairly restrictive. Prequalification requires specific expertise and the understanding of the industry and its characteristics.

APPENDIX B

ACTIVITIES OF THE FOCUS GROUPS

Focus Group meetings were held in four states. State Department of Transportation (DOT) officials attended all of these meetings. Except for the meeting in Kentucky, equal numbers of contractor personnel were in attendance. A copy of the agenda for all of the meetings follows, as do attendance rosters.

The purpose of the meetings was to gather information from industry personnel and to ask their assistance in specifically ascertaining what factors have the greatest impact on construction quality.

To that end, each meeting included hours of discussion followed by the participants filling out a questionnaire, and ranking a list of factors from most important to least important. The research team entered the first Focus Group meeting with a list of fourteen (14) factors that affect construction quality. This list was derived from available documents from DOT's that are used to rate contractor performance, as well as from the experience of team members.

The major accomplishments of the Focus Groups are:

1. Adding factors to the original fourteen (14) proposed by the team to raise the total to nineteen (19) factors, which have an effect on the quality of construction.
2. Paring the list from an unwieldy nineteen (19) factors to a more manageable eight (8). This was accomplished by dropping two factors, and combining the remaining seventeen (17) into a total of eight (8).
3. Ranking the factors from one through eight in order of importance. The final tally was derived from the questionnaire sent out by the team to all DOT's. However, the first results tallied were from the last two Focus Groups.
4. Development of the questionnaire to be sent to all DOT's.
5. Received industry input on such issues as:
    - The use of auditing as a way to rate areas of contractor performance
    - A+B+C Bidding
    - Reciprocity Between States
    - Legal Issues from State to State

6. Allowed the team a glimpse into industry as contractors and DOT personnel discussed these issues. This was extremely valuable, as one could watch the reactions and ascertain what is really - and what is not really - important to these people. It was very interesting to see and get a little understanding of why certain policies are made, how they are enforced – and why reactions to them are sometimes passionate.

It should be understood that the team, when acting as moderator of these meetings, was not "selling" any idea or process, but simply leading the discussion and documenting the comments of participants. The discussions led to issues being added to the study, issues being dropped from the study, and several items being amended, or studied from another perspective.

Below is the agenda used for all of the Focus group meetings:

AGENDA

NCHRP 10-54

FOCUS GROUP MEETING

FLORIDA UTAH KENTUCKY PENNSYLVANIA

1) Introductions
- -Sign-in sheet

2) Brief overview of the project
- -What it is
- -What it is not
- -Your part in it
- -Possible impact
- -Description of the QBPR System
  - -The difference between using past performance to set a bid ceiling and the scope of QBPR

3) What really makes a quality construction project?
  - -Product
  - -Process
- -Is there a difference between a quality product and a quality project?
- -Do DOT's want a quality product or a quality project?

4) Factors to be used in the QBPR System
- -Discussion of what items should be considered (rated)
  - -Contractors: What should I be rated on?
  - -DOT's: What is important for me to know?
- -Generate a list of factors

5) The Rating Process
- -Audit-based?
  - -What would be in it?
- -Questionnaire System?
  - -What would be in it?
    - -Quality - not financial
- -Combination of Audit and Questionnaire
    - -What would be the breakdown?

-How would project size be taken into account?
-How would contractor size be taken into account?
-How would you handle new contractors vs. established ones?
-A+B+C... Price + Time + Quality

6) Reciprocity
-How would we handle reciprocity between DOT's?
-Should we have reciprocity between DOT's?

7) Design Quality and Other Mitigating Factors
-Should designer grading be implemented into the process?
-How would this be accomplished?
-In-house designer
-Consultant designer

8) What Ultimate Form Should This Take?
-Multiplier
-Index
-Rankings

9) Construction Management System
-AASHTO version or State's own version
-How could this be implemented into CMS?
-When will CMS (AASHTO's) be available?

10) Legal Issues
-What is your current appeal process?
-What should the process ideally be?
-What is public knowledge?
-Can information be protected?
-Sunshine Laws, etc.

11) DOT Implementation
-Manpower requirements
-Other hurdles
-How could it be done?

12) Questionnaire
-Come up with questions for a questionnaire to be sent to every state DOT and every state contractors' association. These questions should encompass the day's discussions.

PENNSYLVANIA FOCUS GROUP MEETING MINUTES

A meeting was held at the office of the Associated Pennsylvania Constructors on Thursday, August 7, 1997. Fifteen people representing four contractors, Penn State University, PennDOT, and Associated Pennsylvania Constructors attended the meeting. Following is a chronological recap of the meeting:

- The meeting was called to order by Edward Minchin at 1:00 PM.

- After a brief welcome, Mr. Minchin commenced with the execution of the agenda

Items 1 and 2 – Introductions and Brief Overview of the Project
Each participant introduced himself. A signup sheet was then passed around as Mr. Minchin explained the purpose of the meeting, building upon the information disseminated to the participants via a mailed information sheet.

Item 3 - What really makes a quality construction project?
A quality construction project is a combination of both a quality product and a quality process. Process affects the time required for construction. A long process is bad. Quality problems with the process may be an indication of a disaster waiting to happen. Although some projects may have a successful product in spite of the process, the product will begin to fail with time because the probability of a good product resulting from a bad process is low. Dealing with the public and the media is an important part of the process for achieving a successful project. A quality process and product are inseparable.

Additionally, it was pointed out that the time of process is not simply the contractor's or the DOT's problem but is everybody's problem. The public votes on new taxes to support the system which makes public opinion an important factor for future project funding.

A poor process damages the image of the sponsoring agency. The process problems accumulate from project to project making it important. The process is the same for each project but the product varies.

A good process is not an indicator of a good product. The project may run smoothly with the contractor and the owner getting along and seemingly cooperating quite well however the owner representative is allowing a lot of things to slide. From the outside, the project is moving along quite well while in reality the product will be less than expected.

On the other hand, it was suggested that after a few years the product is the only thing that remains thus making it the most important item. Public opinion will fade with time. However, it was pointed out the reputation of traffic problems that the DOT projects cause follow it from project to project, gathering momentum.

Companies are proud of the fact that they do a good job. However, the most important part of the project is the design. (The design should be the basis against which the contractor is evaluated. They define quality and the contractor can not be expected to exceed the plans and specifications without extra compensation. Therefore, in evaluating the quality of the finished product, the quality of the design should not be evaluated separately.)

In the PennDOT questionnaire there are 8 process questions and 1 product question. In light of this, it seems like the process carries greater importance with the owner. However, this is not true according to PennDOT personnel.

Attitude and cooperation are assessed in the PennDOT PPR. This seems to be a very subjective measure. However the DOT has developed a set of questions that the evaluator answers in the process of computing a score.

Item 4 – Factors
Item 12 - Questionnaire
A list of factors generated by the researchers was passed out and the attendees were asked to list them in order of importance as relates to prequalification. This was originally to be a questionnaire to be mailed out to contractors and DOT personnel nationwide. It was concluded that each of the terms needs to be defined before the questionnaire can be mailed out to the industry. Another conclusion was that the list should be limited to as few factors as possible.

It might be a good idea to separate the people questions from the nonpeople items. It was suggested that combining the two groups creates a large list thus requiring some of the items to have a lower rating even though they are quite important.

If the rest of the process is working properly, safety will generally follow suit. The contractors who have their process in order generally will have safety under control. It was thought to be a very important item however it is heavily dependent upon or the result of other factors.

A contractor's history of filing frivolous claims was suggested as a factor for consideration. However it is important to define this term well because a contractor may have a problem rating themselves based upon an item that is inherent to the process of construction. A large number of claims per project should be a warning sign of a problem contractor. By defining the factor as "frivolous claims," the owner would not be gaining an advantage inducing the contractor to file fewer claims even though the quality of the design may require a significant number. This is one place where the design quality may be of importance in evaluating the ability of the contractor to produce quality projects. It must also be kept in mind that the approach and personality of the DOT representative may influence whether or not claims are filed. It is important to look at claim history and not merely the number of claims filed. The frequency of claims was suggested to be a measurable part of integrity.

Another factor suggested was "adaptability," which they defined as when a contractor has a poor set of plans but the contractor can still build the project. A contractor may be considered adaptable or cooperative if when the plans show something incorrect they come back with a solution to make things work.

Item 5 - The Rating Process
An audit-based rating process will look more at the contract administration while general feeling is that the people part of the project is what is more important.

What is the gain of an audit? If an audit were used, a paperwork procedure would have to be established with a rigid set of guidelines for assessment. One issue of much discussion was over whether an audit would assess files of paperwork that the DOT already has in its files via contractor submissions. The thought was aired that time is being wasted for both the DOT and the contractor to evaluate information that the DOT can access without bothering the contractor. An audit provides hard evidence but should , in most cases, consist of documents that the agency already has.

If the contractor has already submitted the necessary paperwork in the course of a project there is no need to develop another level of bureaucracy.

Should we expect lesser quality on a small project? No, the point comes down to it all being the same. Why should the expectation of quality work be less on a small project?

A one day project gets evaluated the same as a two year project. Should there be some weighting based on project size/length? Yes.

Contractor size should not matter. The projects they complete is what is important, not their size.

One factor that must be kept in mind is that the DOT and the contractor put their best people on the large projects. Therefore, it was suggested that the average of all projects, without a weighting system, would give a fair indication of the contractor's ability to produce quality. This thought was contested.

Item 6 - Reciprocity
All states would need to adopt the system. Or would they? Should a single bad job ban a contractor from doing work in all states? Would an Internet access to contractor ratings help? Maybe?

Neither the contractors nor the DOT personnel thought that this was a priority.

Item 7 - Design Quality
PennDOT rates both in - house designs and those done by consultants. The contractor should not be penalized on a project because of the design quality. (This should not happen with regard to the quality of the final product, however. For factors such as cooperativeness there may be some problems if the contractor has to push issues on a poorly designed job. Frustration developed in both the owner and the contractor over a poorly designed job may affect the rating received by a contractor at the end of a project.)

D/B - Design quality is important for evaluation. However it was the general consensus of the contractors that D/B prequalification and bid evaluation is whole separate topic because it is a different concept.

It was suggested that the investigators talk to New Jersey about their D/B experience (Vince Cortese).

Item 8 - What ultimate form should this take?
Due to the length of this discussion, agenda items 9-11 were dispensed with, as Mr. Minchin expressed a need to leave by 3:30 PM for another obligation. This discussion was quite lively. When the concept of the 'c (quality) factor' was explained, there was reaction all around the table. The original reaction was mixed. The contractors expressed concern with someone having the ability to "play with" the system, and hinder contractors they didn't like or were mad at.

Other contractors were intrigued with the idea of quality work being rewarded, thus disadvantaging "low ballers" and "claims artists." PennDOT personnel were mostly (some very) supportive of the idea from the outset.

Contractors seemed to warm to the idea as the discussion progressed, but stressed objectivity.

The rating system could be an ability factor (multiplier or index). This could be used for anything

The Bureau of Design keeps track of design consultants in this manner.

A + B + C may cause a lot of litigation.

A contractors bid may be reduced by 5% because of his quality rating for the purpose of determining the low bid. To do this one would want to put quality into the process as C and remove it from the ability factor.

By comparing contractor's quality you are comparing different experience.

Will the contractor know his C factor? There is no reason he shouldn't. However, it is not necessary for these to be published numbers for every contractor to know. This should be a known number so that no one can play with the numbers when prices are submitted.

If quality is used in bidding, the contractor will pay much more attention to the performance review thus returning their focus to quality.

Currently PennDOT gives a new contractor a base capacity number for approved categories of work and allows the capacity to increase at a set rate each year.

All parties expressed great interest in the potential of this and in seeing the finished product.

PennDOT and Contractor personnel all requested at least one follow-up meeting to see what progress is being made and to see what the other states are saying.

APC and PennDOT agreed to distribute the questionnaire to their respective members.

Mr. Minchin closed the meeting at 3:35 PM.

LIST OF PENNSYLVANIA FOCUS GROUP ATTENDEES

NAME	AFFILIATION
Ron L. Geist	Associated Pennsylvania Constructors
Scott Fletcher	PennDOT
Joe Meehan	PennDOT
Bert Golden	PennDOT
John Davidyock	PennDOT
Russell Neal	PennDOT
Tom Fruehstorfer	PennDOT
Edward Minchin	Penn State
Todd Arnold	Penn State
Fred Starasinic	PennDOT
Neal Smith	Eastern Industries
Lew Hoover	Broadhead Construction Co.
R.E. Hirschman	Elderlee, Inc.
Hank Heck	Associated Pennsylvania Constructors
Bill Cummings	Tony DePaul & Son

FLORIDA FOCUS GROUP MEETING MINUTES

The meeting began at 1:30 PM on August 28, 1997 and was held at the FDOT District 7, Headquarters in Tampa, Florida. Dr. Ralph Ellis chaired the meeting. The agenda for the meeting followed the agenda previously established for NCHRP 10-54 Focus Group Meetings. The meeting was not electronically recorded, however, handwritten notes of the participants comments were made. These comments are enclosed with these minutes and are believed to represent the comments of the participants without editing. In the following minutes, a "sense of the discussion" has been added under each of the topics. This is the opinion of the Chair based upon his participation and a review of the notes taken.

It should be noted that the FDOT has in place a well structured QBPR system used for Contractor Pre-Qualification.

Introduction
Dr. Ellis began the meeting by introducing himself and having the participants introduce themselves. A copy of the attendance list is enclosed.

Overview of the Research Project
An overview of the project was presented by Dr. Ellis. This included a review of the project scope and a discussion of the objectives. Dr. Ellis made the point that he was there to objectively record the opinions and comments of the participants without bias.

What really makes a Quality Project?
Dr. Ellis explained that both the end product and the process to reach the end are part of project quality. The group seemed to feel that the product was most important. There was considerable skepticism as to whether the process could be objectively measured given the human factors involved.

Factors to be used in the QBPR System
Dr. Ellis reviewed the list of Candidate Factors and definitions previously established. Most of the Contractor participants felt that claims were not an appropriate measure of performance particularly when they were ultimately settled. The participants were asked to rate the Factors, and add any additional factors that they felt important. The result of the survey questionnaire is enclosed.

The Rating System
The participants, both FDOT and contractor, appeared to be satisfied with the current FDOT QBPR system. Apparently considerable effort has been made to minimize the subjectivity of the system. New contractors are given a neutral rating. Project size and contractor size did not seem to be relevant to the issue of quality.
When presented with the suggestion that the QBPR might be used as a factor in bidding (A+B+C), considerable doubt was expressed concerning whether it could be fairly administered. The consequences of giving a competitive advantage to some contractors were discussed.

Reciprocity
Using the QBPR across state lines may have some advantages but appeared to be difficult to make work. Each State Highway Agency now has their own system.

Design Quality
Florida has a rating system for design consultants. It is now part of the QBPR for contractors. The elements of the design rating did not appear to match well with constructability considerations.

Construction Management System
Some of the data required by the QBPR could be managed by the CMS when it is available.

Legal Systems
Both Bidding and Pre-Qualification in Florida are covered by State Statue. Any changes will require legislative action. Currently financial information can be protected.

Questionnaire
All participants completed the QBPR factors survey. Results of the survey are enclosed.

The meeting was adjourned following the survey at approximately 3:40 PM.

LIST OF FLORIDA FOCUS GROUP ATTENDEES

NAME	AFFILIATION
Alan Adderly	FDOT
Ken Leuderalbert	FDOT
Sandy Piccirilli	FDOT
Charles Goodman	FDOT
Micheal Kopotic	FDOT
John Brandnik	FDOT
Andy Clark	LeWare Construction Co.
Bob Burleson	Florida Transportation Builders Association
Rammy Cone	Cone and Graham
Mike Horan	AJAX Paving Industries
J.L. Cone	Cone Constructors
Don Sollie	Couch Construction
Ralph Ellis	Moderator

KENTUCKY FOCUS GROUP MEETING MINUTES

The meeting was held at the Kentucky Transportation Cabinet's main office building in Frankfort, Kentucky on September 26, 1997. The nine participants were mid and upper level management personnel responsible for implementation of prequalification and monitoring construction contracts. A roster of participants was not obtained. Unlike other focus groups, this particular arrangement was suitable due to the recent efforts in Kentucky to prequalify contractors for the Paris Pike project. Kentucky addressed many of the issues being considered by the research team in the planning phases of that project.

G. Smith called the meeting to order at 8:00 am. A tape recording of the meeting was used to support handwritten minutes. The meeting agenda is appended to these minutes.

Agenda Items 1 and 2
After a brief welcome and personal introduction, G. Smith presented an overview of the project and the proposed agenda for the meeting. Several questions regarding current findings of the project team were discussed and the meeting proceeded into the main agenda items. Little discussion was needed to describe terms or to provide additional focus on the issues. The participants, having previous experiences, were prepared with their comments. The standard agenda was followed, but keeping focus on some sections was difficult due to tangential issues. Kentucky has used a modified prequalification process on an experimental basis for the Paris Pike project. Details of the project influenced discussion, but did not dominate the fact-finding portion to any noticeable degree.

Agenda Items 3 and 4
Separation of quality project and factors to consider was difficult. The discussion confounded the two and the comments collected together. Various perspectives generally described a quality project. From the measurement side, a project that rides good, looks good, and the materials conform to specifications were considered quality projects. If the schedule was maintained as promised and the project meets scheduled deadlines was also felt to be important. The public tends to holler when roads are not opened on the scheduled opening dates. Effective traffic maintenance was also considered by the group as important criteria in a quality project, given the number of projects requiring traffic maintenance. Less measurable items were factors like: contractors, who spent time and effort looking for better ways to do construction and minimize claims, well organized contractors, and contractors who planned activities ahead of time.

The quality of the design that the contractor worked with was discussed as a quality project factor. A design evaluation should be part of the project evaluation. The Kentucky Paris Pike project includes contractor constructability reviews during design. The work is paid at $25 per hour of review time. Change orders, one possible indicator of design problems, are not tracked. It is generally recognized that a need exists to track and identify the general source of design problems. Concurrently a best practice database should be developed.

UTAH FOCUS GROUP MEETING MINUTES

The meeting began at 1:00 PM on January 21, 1998 and was held at the AGC offices in Salt Lake City, Utah. Dr. Ralph Ellis chaired the meeting. The agenda for the meeting followed the agenda previously established for NCHRP 10-54 Focus Group Meetings.

The meeting was not electronically recorded; however, handwritten notes of the participant's comments were made. These comments are enclosed with these minutes and are believed to represent the comments of the participants without editing. In the following minutes, a "sense of the discussion" has been added under each of the topics. This is the opinion of the Chair based upon his participation and a review of the notes taken.

It should be noted that the UDOT has in place a well-structured QBPR system used for Contractor Pre-Qualification.

Introduction
Dr. Ellis began the meeting by introducing himself and having the participants introduce themselves. A copy of the attendance list is enclosed.

Overview of the Research Report
Dr. Ellis presented an overview of the project. This included a review of the project scope and a discussion of the objectives. Dr. Ellis made the point that he was there to objectively record the opinions and comments of the participants without bias.

What really makes a Quality Project?
Dr. Ellis explained that both the end product and the process to reach the end are part of project quality. The group expressed concern over the inherent subjectivity of a rating system.

Factors to be used in the QBPR System
Dr. Ellis reviewed the list of Candidate Factors and definitions previously established. The participants were asked to rate the Factors, and add any additional factors that they felt important. The result of the survey questionnaire is enclosed.

The Rating System
UDOT is working on a revision to its rating system. Their concept is to develop a list of questions (perhaps as many as 100) that would be answered by the UDOT project engineer. The questions would be framed so that either a positive or negative answer would be obvious. The contractor's rating would then be based on the score obtained. This would minimize individual subjectivity in the system.
One suggestion was to use a two level rating system. Basic organizational qualifications would make up the First Level. A Second Level would be composed of project

performance measures. Bidders might be selected to bid based upon the strength of their First and Second Level ratings.

Reciprocity
Using the QBPR across state lines may have some advantages but appeared to be difficult to make work. Each State Highway Agency now has their own system.

Design Quality
UDOT now has a rating system for design consultants.

Design Quality
UDOT now has a rating system for design consultants.

Construction Management System
The Project Engineer would reference project information when preparing the rating.

Legal Systems
Both Bidding and Pre-Qualification in Utah are covered by State Statue. Any changes will require legislative action. Currently financial information can be protected.

Questionnaire
All participants completed the QBPR factors survey. Results of the survey are enclosed.

The meeting was adjourned following the survey at approximately 4:00 PM.

Comments of Participants

Why do we need a rating system?

Rating systems are inherently subjective.

Project factors such as the complexity of the project will effect the rating. It would be easier to get a good rating on an easy project.

The quality of the design and specifications will effect the contractor's rating.

Bonding by sureties provides a measure of the contractor's performance rating.

Specified project durations are shrinking. This adds to project performance problems.

A + B contracting forces too much time pressure. It is not good to work your people 7 days a week.

A + B contracting has a bias against small contractors.

AGC Highway Committee is against having the Designer being the Construction Engineer because of possible conflicts of interest.

Utah assigns a Project Manager who stays with the project from design through construction.

Utah has only has one construction claim go to the board in 5 years.

There needs to be a dialog between the DOT and the Contractor concerning the Performance Rating as the project progresses not just at the end.

General Contractor is responsible for subcontract work. Sub performance should count.

LIST OF UTAH FOCUS GROUP ATTENDEES

NAME	AFFILIATION
Peter Negus	UDOT
Bob Westover	UDOT
Paul Clyde	W.W. Clyde & Co.
Judy Jamarillo	UDOT
Larry Buss	UDOT
Hugh Kirkham	UDOT
Joe Woodley	Harper Contracting
Jack Parson	Jack B. Parson Co.'s
J.D. McNeil	J.D. McNeil Construction
Guy Wadsworth	Wadsworth Brothers
Paul Johnson	LeGrand Johnson Construction
Rich Thorn	Associated General Contractors
Ralph Ellis	Moderator

APPENDIX C

DATA GATHERING AND ANALYSIS

INTERIM PROJECT QUESTIONNAIRE

I. PERSONNEL

1) Did the contractor fill the trainee positions with qualified workers?

2) Does the contractor have a written EEO Policy?

3) Were any complaints about contractor field personnel behavior registered by the public?

4) Did the contractor always give proper notice of claim?

5) Did the subcontractors meet EEO requirements?

II. PROJECT MANAGEMENT / CONTROL SKILLS

1) Does the contractor have a Quality Control Plan in place?

2) If so, is this Quality Control Plan closely followed?

3) Did the contractor move or destroy agency-controlled or agency-requested survey markers?

4) Did the contractor provide and follow a Safety Plan for the project?

5) Were manufacturer certificates of compliance or departmental certification documents or stamps submitted with the delivery of materials to the project?

6) Were any materials or work paid for at a reduced rate due to them not meeting specifications?

7) Did the contractor require all subcontractors to submit a written safety plan?

8) Did the contractor meet all hazardous material requirements?

9) Did the contractor meet air quality requirements?

10) Did the contractor provide environmental clearances when needed?

11) Were there any violations of the National Pollution Discharge Elimination System (NPDES) on this project?

12) Did the contractor ever use materials that were not on the Qualified Products List?

13) Did contractor's employees register any valid complaints about their wages?

14) Were labor compliance problems answered and resolved within one pay period?

15) Did contractor payrolls always indicate the correct employee position and the correct employee wage?

16) Were there any valid complaints from subcontractors about their not being paid?

17) Were there any valid complaints from material suppliers about their not being paid?

18) Did the contractor always follow the contract documents for Maintenance of Traffic?

19) Did the contractor ever refuse to make changes in the status quo in personnel, equipment or procedure in order to eliminate a problem on the project?

III. SCHEDULE ADHERENCE

1) Did the contractor follow the project schedule?

2) Did the contractor ever adjust staffing to keep the project on schedule?

3) Does the contractor consistently meet document submittal deadlines?

IV. CONTRACTOR ORGANIZATION

1) Did the contractor follow the approved Erosion Control Plan?

2) Were requests to the contractor for prices for extra work answered within three working days?

3) Were shop drawings submitted to the Department within the time called for in the contract?

V. PLANT AND EQUIPMENT

1) Did the project ever experience delay because the contractor's equipment or plant ceased to work properly?

2) Did any one piece of equipment or any one plant cease to function, causing more than one delay?

END OF PROJECT QUESTIONNAIRE

I. PERSONNEL

1) Does the contractor's general management contribute to solving project problems?

2) Did the contractor have an approved training program prior to hiring trainees?

3) Did the contractor use 90% the trainee hours allotted by the contract?

4) Did the contractor meet the EEO hiring commitment?

5) Does the contractor have a written EEO Policy?

6) Did the contractor meet the women and minority (DBE) commitment?

7) Were any complaints about contractor field personnel behavior registered by the public?

8) Did the contractor always give proper notice of claim?

9) Did the subcontractors meet EEO hiring requirements?

10) Did the contractor ever refuse or decline to meet with department personnel to discuss a problem on the project?

11) Was there ever a time when the project was delayed because the contractor didn't have the project properly staffed?

II. PROJECT MANAGEMENT / CONTROL SKILLS

1) Does the contractor have a Quality Control Plan in place?

2) If so, was this Quality Control Plan closely followed?

3) Did the contractor experience accidents categorized as "doctor cases" or "lost time accidents" on the project?

4) Did the contractor move or destroy agency-controlled or agency-requested survey markers?

5) Did the contractor provide and follow a Safety Plan for the project?
6) Were manufacturer certificates of compliance or departmental certification documents or stamps submitted with the delivery of materials to the project?

7) Were materials installed or placed in accordance with specifications or manufacturer requirements?

8) Were any materials or work paid for at a reduced rate due to them not meeting specification?

9) Did the contractor require all subcontractors to submit a written safety plan?

10) Did the contractor meet all hazardous material requirements?

11) Did the contractor meet air quality requirements?

12) Did the contractor provide environmental clearances when needed?

13) Were there any violations of the National Pollution Discharge Elimination System (NPDES) on this project?

14) Did the contractor ever use or attempt to use materials that were not on the Qualified Products List?

15) Did contractor's employees register any valid complaints about their wages?

16) Were labor compliance problems answered and resolved within one pay period?

17) Did contractor payrolls always indicate the correct employee position and correct wage?

18) Were there any valid complaints from subcontractors about their not being paid by the prime?

19) Were there any valid complaints from material suppliers about their not being paid by the prime?

20) Did the contractor follow the contract documents for Maintenance of Traffic?

21) Was a Traffic Control Plan submitted and approved before work commenced?

22) Did the contractor ever refuse to make changes in the status quo in personnel, equipment, or procedures in order to alleviate a problem on the project?

III. SCHEDULE ADHERENCE

1) Did the contractor follow the project schedule?

2) Did the contractor start the work on time?

3) Did the contractor complete the work on time?

4) Did the contractor maintain an up-to-date project schedule throughout the project?

5) Did the contractor ever adjust project staffing according to the project status in regards to the project schedule?

6) Was the project accepted on the first final inspection?

7) Does the contractor consistently meet document submittal deadlines?

8) Did the contractor furnish final documentation within 15 days of notification?

IV. CONTRACTOR ORGANIZATION

1) Did the contractor meet the project's DBE goal?

2) Did the contractor follow the approved Traffic Control Plan?

3) Did the contractor always have subcontracts approved prior to the subcontractor going to work?

4) Did the contractor closely follow the approved Erosion Control Plan?

5) Were requests to the contractor for prices for extra work always answered within three working days?

6) Were shop drawings submitted to the Department within the time called for in the contract?

7) Did the contractor have someone with decision-making authority on the project at all times?

V. PLANT AND EQUIPMENT

1) Did the project ever experience delay because the contractor's equipment or plant ceased to work properly?

2) Did any one piece of equipment or any one plant cease to function, causing more than one delay?

QUESTIONNAIRE FOR DISTRICT OR STATE OFFICE

TO BE FILLED OUT AFTER PROJECT COMPLETION BY DISTRICT OFFICE OR STATE OFFICE PERSONNEL

1) Is the contractor's Experience Modifier less than 1.0 as of the end of the project?

2) Is the contractor's OSHA Incident Rate less than 5.0 as of the end of the project?

3) As of the end of this project, has the contractor, when acting as a prime contractor, completed 90% of all projects on time or ahead of time over the last five years?

- **This is the form that was filled out by project personnel during the data -gathering phase of this research project. A similar form would be filled out for the Interim and District/State Questionnaires**

END OF PROJECT QUESTIONNAIRE

Answer Sheet

STATE ______________________________ **DATE** __________________

PROJECT NUMBER ______________________ **YEAR COMPLETED** ________

PROJECT ENGINEER/LEAD INSPECTOR ________________________________

I. PERSONNEL

1)	YES	NO	N/A
2)	YES	NO	N/A
3)	YES	NO	N/A
4)	YES	NO	N/A
5)	YES	NO	N/A
6)	YES	NO	N/A
7)	YES	NO	N/A
8)	YES	NO	N/A
9)	YES	NO	N/A
10)	YES	NO	N/A
11)	YES	NO	N/A

II. PROJECT MANAGEMENT / CONTROL SKILLS

1)	YES	NO	N/A

2)	YES	NO	N/A
3)	YES	NO	N/A
4)	YES	NO	N/A
5)	YES	NO	N/A
6)	YES	NO	N/A
7)	YES	NO	N/A
8)	YES	NO	N/A
9)	YES	NO	N/A
10)	YES	NO	N/A
11)	YES	NO	N/A
12)	YES	NO	N/A
13)	YES	NO	N/A
14)	YES	NO	N/A
15)	YES	NO	N/A
16)	YES	NO	N/A
17)	YES	NO	N/A
18)	YES	NO	N/A
19)	YES	NO	N/A
20)	YES	NO	N/A
21)	YES	NO	N/A
22)	YES	NO	N/A

III. SCHEDULE ADHERENCE

1)	YES	NO	N/A
2)	YES	NO	N/A

3)	YES	NO	N/A
4)	YES	NO	N/A
5)	YES	NO	N/A
6)	YES	NO	N/A
7)	YES	NO	N/A
8)	YES	NO	N/A

IV. CONTRACTOR ORGANIZATION

1)	YES	NO	N/A
2)	YES	NO	N/A
3)	YES	NO	N/A
4)	YES	NO	N/A
5)	YES	NO	N/A
6)	YES	NO	N/A
7)	YES	NO	N/A

V. PLANT AND EQUIPMENT

1)	YES	NO	N/A
2)	YES	NO	N/A

- **This is the form filled out by project personnel in Iowa, Indiana, and Pennsylvania (Florida provided a complete test-results computer printout for each project) that provided the test results necessary to generate the PPFd**

MEASUREMENT AND TESTING FORM

STATE ______________________________ **DATE** _________________

PROJECT NUMBER ________________________________

PAY ITEM	NUMBER OF TESTS	NUMBER WITHIN LIMITS	PERCENT WITHIN LIMITS

GUIDELINES FOR INTERIM PROJECT QUESTIONNAIRE

I. PERSONNEL

1) If the trainee positions were filled by people who contributed to the completion of the project, the answer is "yes." If the positions went unfilled or were filled with people who were not required to contribute, the answer is "no."

2) "Yes" or "No"

3) "Yes" or "No"

4) Always means always - "Yes" or "No."

5) May not be applicable. If not, answer "N/A." If applicable, 75% of the interim report period the subcontractor must meet the EEO requirements (for a monthly interim report period at least three weeks in compliance) for the project in order to qualify for a "yes" response.

II. PROJECT MANAGEMENT / CONTROL SKILLS

1) "Yes" or "No"

2) If it was discovered more than one time during the interim report period that the contractor has deviated from the project's approved Quality Control Plan, the answer is "No," otherwise, the answer is "Yes."

3) If it was discovered more than one time during the interim report period that the contractor has accidentally moved or destroyed the markers, the answer is "Yes." Also, any deliberate moving of the markers should result in an answer of "Yes." Otherwise, the answer is "No."

4) May not be applicable. If not, answer "N/A." If applicable, if it was discovered more than one time during the interim report period that the contractor has deviated from the project's approved Safety Plan, the answer is "No," otherwise, the answer is "Yes."

5) If submitted 95% of the time during the interim report period, the answer is "Yes," otherwise, the answer is "No."

6) "Yes" or "No"

7) May not be applicable. If not, answer "N/A." If applicable, "Yes" or "No."

8) May not be applicable. If not, answer "N/A." If applicable, "Yes" or "No."

9) May not be applicable. If not, answer “N/A.” If applicable, “Yes” or “No.”

10) May not be applicable. If not, answer “N/A.” If applicable, “Yes” or “No.”

11) “Yes” or “No”

12) “Yes” or “No”

13) “Yes” or “No”

14) “Yes” or “No”

15) If, during the interim report period, there were no discoveries of incorrect employee position, or of incorrect employee wage, the answer is “Yes.” If there was no more than one discovery of either, and the problem was corrected within one pay period, the answer is “Yes.” Otherwise the answer is “No.”

16) “Yes” or “No”

17) “Yes” or “No”

18) If it was discovered more than one time during the interim report period that the contractor has deviated from the project’s approved Traffic Control Plan, the answer is “No,” otherwise, the answer is “Yes.”

19) “Yes” or “No”

III. SCHEDULE ADHERENCE

1) If there was any time during the interim report period when the contractor was at least ten percent behind the project schedule, the answer is “No.” Otherwise, the answer is “Yes.”

2) May not be applicable if progress and schedule was never an issue. If applicable, if the contractor voluntarily moved people onto the project, or reassigned people within the project to increase production, the answer is “Yes.” Otherwise, the answer is “No.”

3) If, during the interim report period, the contractor submitted any required document late, the answer is “No.” Otherwise, the answer is “Yes.”

IV. CONTRACTOR ORGANIZATION

1) May not be applicable. If not, answer “N/A.” If applicable, if it was discovered more than one time during the interim report period that the contractor has deviated

from the project's approved Erosion Control Plan, the answer is "No," otherwise, the answer is "Yes."

2) May not be applicable. If not, answer "N/A." If applicable, "Yes" or "No."

3) May not be applicable. If not, answer "N/A." If applicable, "Yes" or "No."

V. PLANT AND EQUIPMENT

1) "Yes" or "No"

2) "Yes" or "No"

GUIDELINES FOR END OF THE PROJECT QUESTIONNAIRE

I. PERSONNEL

1) If more than one problem on the project were made worse by the problem being shared with top officials (not project personnel) of the contractor, the answer is "No." Otherwise, the problem is "Yes," unless no problems were ever shared with the top officers of the contractor in which case the answer is "N/A."

2) "Yes" or "No"

3) "Yes" or "No"

4) This is NOT the DBE goal. May not be applicable ("N/A"), but if there are EEO statutes in this state, or EEO requirements in the contract, and if they were followed 90% of the time, the answer is "Yes." Otherwise, the answer is "No."

5) "Yes" or "No"

6) This is NOT the DBE goal. May not be applicable ("N/A"), but if there are statutes in this state requiring a certain number or percentage of women or minority employees, or like requirements in the contract, and if they were followed 90% of the time, the answer is "Yes." Otherwise, the answer is "No."

7) "Yes" or "No"

8) ALWAYS - "Yes" or "No"

9) May not be applicable, but if statute or contract requires the subcontractors to follow EEO requirements, and if they were followed 90% of the time, the answer is "Yes." Otherwise, the answer is "No."

10) "Yes" or "No"

11) "Yes" or "No"

II. PROJECT MANAGEMENT / CONTROL SKILLS

1) "Yes" or "No"

2) If the contractor was observed more than twice during the length of the project deviating from the contract Quality Control Plan for any item , the answer is "No." Otherwise, the answer is "Yes."

3) “Yes” or “No”

4) If it was discovered more than twice during the project that the contractor has accidentally moved or destroyed the markers, the answer is “Yes.” Also, any deliberate moving of the markers should result in an answer of “Yes.” Otherwise, the answer is “No.”

5) May not be applicable. If not, answer “N/A.” If applicable, if it was discovered more than twice during the project that the contractor has deviated from the project’s approved Safety Plan, the answer is “No,” otherwise, the answer is “Yes.”

6) If submitted 95% of the time during the interim report period, the answer is “Yes,” otherwise, the answer is “No.”

7) More than 95% of the time? If so, the answer is “Yes.” Otherwise, the answer is “No.”

8) “Yes” or “No”

9) May not be applicable. If not, answer “N/A.” If applicable, “Yes” or “No.”

10) May not be applicable. If not, answer “N/A.” If applicable, “Yes” or “No.”

11) May not be applicable. If not, answer “N/A.” If applicable, “Yes” or “No.”

12) May not be applicable. If not, answer “N/A.” If applicable, “Yes” or “No.”

13) “Yes” or “No”

14) “Yes” or “No”

15) “Yes” or “No”

16) “Yes” or “No”

17) If, during the project, there were no discoveries of incorrect employee position, or of incorrect employee wage, the answer is “Yes.” If there was no more than two discoveries of either, and the problem(s) was corrected within one pay period, the answer is “Yes.” Otherwise the answer is “No.”

18) “Yes” or “No”

19) “Yes” or “No”

20) If it was discovered more than three times during the project that the contractor deviated from the project’s approved Traffic Control Plan, the answer is “No,” otherwise, the answer is “Yes.”

21) “Yes” or “No”

22) “Yes” or “No”

III. SCHEDULE ADHERENCE

1) If there was any time during the interim report period when the contractor was at least ten percent behind the project schedule, the answer is “No.” Otherwise, the answer is “Yes.”

2) “Yes” or “No”

3) “Yes” or “No” – Of course, any additional days granted the contractor must be taken into consideration.

4) Was the contractor observed more than once during the life of the construction project with a printed schedule that was more than a week out of sync with reality? If so, the answer is “No.” Otherwise, the answer is “Yes.”

5) May not be applicable. If applicable, if the contractor voluntarily moved people onto the project, or reassigned people within the project to increase production, the answer is “Yes.” Otherwise, the answer is “No.”

6) If the project was conditionally accepted with only a short, expected “punch list” of items for the contractor to perform, the answer is “Yes.” If the contractor was given an unusually long list of items to perform for conditional acceptance, or if the contract was not accepted even conditionally, the answer is “No.”

7) If, during the project, the contractor submitted more than one required document late, the answer is “No.” Otherwise, the answer is “Yes.”

8) “Yes” or “No”

IV. CONTRACTOR ORGANIZATION

1) “Yes” or “No”

2) If it was discovered more than three times during the project that the contractor has deviated in any way from the project’s approved Traffic Control Plan, the answer is “No,” otherwise, the answer is “Yes.”

3) ALWAYS - “Yes” or “No”

4) May not be applicable. If not, answer “N/A.” If applicable, if it was discovered more than twice during the project that the contractor has deviated from the project’s approved Erosion Control Plan, the answer is “No,” otherwise, the answer is “Yes.”

5) ALWAYS (If applicable) - “Yes” or “No”

6) ALWAYS (If applicable) - “Yes” or “No”

7) ALWAYS (during working hours or while construction was taking place) - “Yes” or “No”

V. PLANT AND EQUIPMENT

1) “Yes” or “No”

2) “Yes” or “No”

GUIDELINES FOR DISTRICT OR STATE OFFICE QUESTIONNAIRE

1) “Yes” or “No”

2) “Yes” or “No”

3) “Yes” or “No” – regardless of the number of projects the contractor has performed

CHARTS AND GRAPHS

- **ALL FOUR STATES**
- **FLORIDA**
- **IOWA**
- **INDIANA**
- **PENNSYLVANIA**

Figure 1. four States' Projects - Evaluation Results v. Test Results

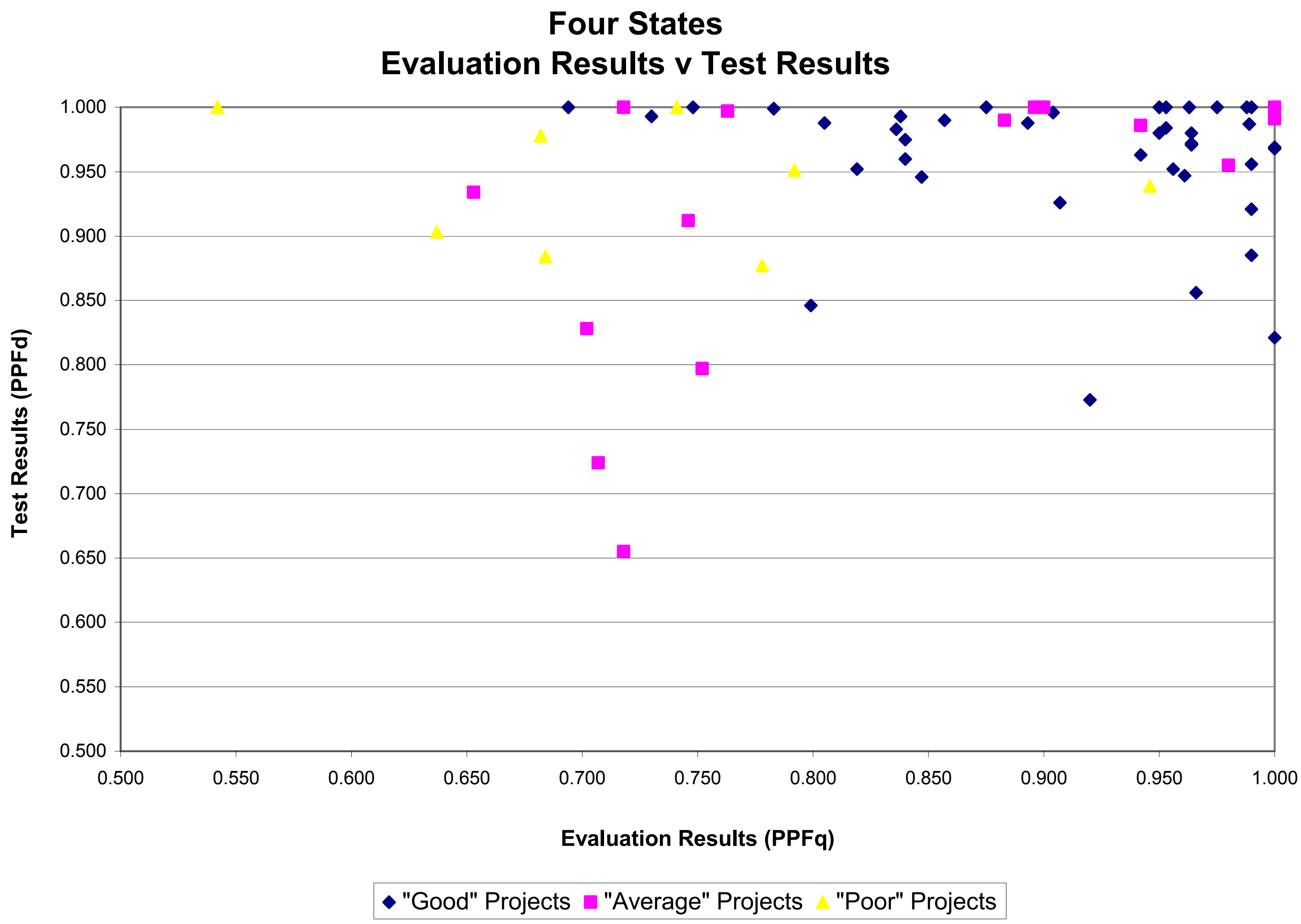


Table 1. All Four States by DOT Rating

Project	PPFq	PPFd	PPF	DOT Rating	Type Project	Avg.PPFq	Avg.PPFd	Avg.PPF
21089615201	1.000	0.821	0.964	Good	ACC Pavement			
20823515201	0.950	1.000	0.960	Good	ACC Pavement			
21330015201	0.819	0.952	0.846	Good	ACC Pavement			
20840815201	0.730	0.993	0.783	Good	ACC Pavement			
20777915201	1.000	0.969	0.994	Good	ACC Pavement			
21080015201	0.990	0.885	0.969	Good	ACC Pavement			
38020-3526	1.000	0.968	0.994	Good	ACC Pavement			
21002015201	0.799	0.846	0.808	Good	ACC Pavement			
21042915201 &	0.988	1.000	0.990	Good	ACC Pavement			
O21115	0.966	0.856	0.944	Good	ACC Pavement			
O22143	0.907	0.926	0.911	Good	ACC Pavement			
O91602	0.953	1.000	0.962	Good	ACC Pavement			
O91701	0.990	1.000	0.992	Good	ACC Pavement			
O91710	0.975	1.000	0.980	Good	ACC Pavement			
O92101	0.875	1.000	0.900	Good	ACC Pavement			
O91065	0.964	0.972	0.966	Good	ACC Pavement			
O91716	0.963	1.000	0.970	Good	ACC Pavement			
O95023	0.964	0.971	0.965	Good	ACC Pavement	0.911	0.961	0.921
103069	0.942	0.963	0.946	Good	ACC Pavement			
19351	0.990	0.921	0.976	Good	ACC Pavement			
22925	0.920	0.773	0.891	Good	ACC Pavement			
22677	0.964	0.980	0.967	Good	ACC Pavement			
22967	0.840	0.960	0.864	Good	ACC Pavement			
21207815201	0.847	0.946	0.867	Good	Bridge			
21137315201	0.950	0.980	0.956	Good	Bridge			
50020-3524	0.893	0.988	0.912	Good	Bridge			
O91040	0.953	0.984	0.959	Good	Bridge			
O91086	1.000	1.000	1.000	Good	Bridge			
20839115201 &	0.840	0.975	0.867	Good	Combination (B/A)			
O27051	0.748	1.000	0.798	Good	Combination (B/A)			
O91092	0.989	0.987	0.989	Good	Combination (B/A)			
O92081	0.783	0.999	0.826	Good	Bridge			
6006 - PS2	0.805	0.988	0.842	Good	PCC Pavement			
O43228	0.836	0.983	0.865	Good	PCC Pavement			
O54059	0.904	0.996	0.922	Good	PCC Pavement			
20961	0.694	1.000	0.755	Good	PCC Pavement			
23060	0.990	0.956	0.983	Good	PCC Pavement			
20307	0.961	0.947	0.958	Good	PCC Pavement			
97	0.857	0.990	0.884	Good	PCC Pavement			
19	0.838	0.993	0.869	Good	PCC Pavement			
22	0.956	0.952	0.955	Good	PCC Pavement			
O22142	1.000	1.000	1.000	Average	ACC Pavement			
O21118	0.752	0.797	0.761	Average	ACC Pavement			
23391	0.718	0.655	0.705	Average	ACC Pavement			
21063815201	0.896	1.000	0.917	Average	Bridge			
O92086	1.000	0.991	0.998	Average	ACC Pavement			
SR 78-029	0.980	0.955	0.975	Average	ACC Pavement			
102144	0.900	1.000	0.920	Average	Bridge			

21969	0.702	0.828	0.727	Average	ACC Pavement	0.824	0.918	0.843
O23029	0.942	0.986	0.951	Average	PCC Pavement			
6006 - #1	0.763	0.997	0.810	Average	PCC Pavement			
O93131	0.746	0.912	0.779	Average	PCC Pavement			
23391	0.718	1.000	0.774	Average	PCC Pavement			
19515	0.883	0.990	0.904	Average	PCC Pavement			
160	0.653	0.934	0.709	Average	PCC Pavement			
40	0.707	0.724	0.710	Average	PCC Pavement			
O25070	0.946	0.939	0.945	Poor	ACC Pavement			
19394	0.682	0.978	0.741	Poor	PCC Pavement			
O42259	0.637	0.903	0.690	Poor	ACC Pavement			
104165	0.741	1.000	0.793	Poor	ACC Pavement			
SR 191-02B	0.792	0.951	0.824	Poor	Bridge	0.725	0.942	0.769
20936315201	0.684	0.884	0.724	Poor	Combination (B/A)			
18	0.778	0.877	0.798	Poor	PCC Pavement			
96	0.542	1.000	0.634	Poor	PCC Pavement			

Table 2. All Four States by Project Type

Project	PPFq	PPFd	PPF	DOT Rating	Type Project	Avg.PPFq	Avg.PPFd	Avg.PPF
21089615201	1.000	0.821	0.964	Good	ACC Pavement			
20823515201	0.950	1.000	0.960	Good	ACC Pavement			
21330015201	0.819	0.952	0.846	Good	ACC Pavement			
20840815201	0.730	0.993	0.783	Good	ACC Pavement			
20777915201	1.000	0.969	0.994	Good	ACC Pavement			
21080015201	0.990	0.885	0.969	Good	ACC Pavement			
38020-3526	1.000	0.968	0.994	Good	ACC Pavement			
21002015201	0.799	0.846	0.808	Good	ACC Pavement			
21042915201 &	0.988	1.000	0.990	Good	ACC Pavement			
O21115	0.966	0.856	0.944	Good	ACC Pavement			
O22142	1.000	1.000	1.000	Average	ACC Pavement			
O21118	0.752	0.797	0.761	Average	ACC Pavement			
O25070	0.946	0.939	0.945	Poor	ACC Pavement			
O22143	0.907	0.926	0.911	Good	ACC Pavement			
O42259	0.637	0.903	0.690	Poor	ACC Pavement	0.905	0.932	0.911
SR 78-029	0.980	0.955	0.975	Average	ACC Pavement			
O91602	0.953	1.000	0.962	Good	ACC Pavement			
O91701	0.990	1.000	0.992	Good	ACC Pavement			
O91710	0.975	1.000	0.980	Good	ACC Pavement			
O92086	1.000	0.991	0.998	Average	ACC Pavement			
O92101	0.875	1.000	0.900	Good	ACC Pavement			
O91065	0.964	0.972	0.966	Good	ACC Pavement			
O91716	0.963	1.000	0.970	Good	ACC Pavement			
O95023	0.964	0.971	0.965	Good	ACC Pavement			
104165	0.741	1.000	0.793	Poor	ACC Pavement			
103069	0.942	0.963	0.946	Good	ACC Pavement			
19351	0.990	0.921	0.976	Good	ACC Pavement			
22925	0.920	0.773	0.891	Good	ACC Pavement			
21969	0.702	0.828	0.727	Average	ACC Pavement			
22677	0.964	0.980	0.967	Good	ACC Pavement			
22967	0.840	0.960	0.864	Good	ACC Pavement			
23391	0.718	0.655	0.705	Average	ACC Pavement	*		
21063815201	0.896	1.000	0.917	Average	Bridge			
21207815201	0.847	0.946	0.867	Good	Bridge			
21137315201	0.950	0.980	0.956	Good	Bridge			
50020-3524	0.893	0.988	0.912	Good	Bridge			
O91040	0.953	0.984	0.959	Good	Bridge	0.890	0.983	0.909
O91086	1.000	1.000	1.000	Good	Bridge			
SR 191-02B	0.792	0.951	0.824	Poor	Bridge			
O92081	0.783	0.999	0.826	Good	Bridge			
102144	0.900	1.000	0.920	Average	Bridge	*		
20936315201	0.684	0.884	0.724	Below Avg.	Combination (B/A)			
20839115201 &	0.840	0.975	0.867	Good	Combination (B/A)	0.815	0.962	0.845
O27051	0.748	1.000	0.798	Good	Combination (B/A)			
O91092	0.989	0.987	0.989	Good	Combination (B/A)	*		

O23029	0.942	0.986	0.951	Average	PCC Pavement			
6006 - #1	0.763	0.997	0.810	Average	PCC Pavement			
6006 - PS2	0.805	0.988	0.842	Good	PCC Pavement			
O43228	0.836	0.983	0.865	Good	PCC Pavement	0.803	0.958	0.834
O54059	0.904	0.996	0.922	Good	PCC Pavement			
O93131	0.746	0.912	0.779	Average	PCC Pavement			
20961	0.694	1.000	0.755	Good	PCC Pavement			
23391	0.718	1.000	0.774	Average	PCC Pavement			
23060	0.990	0.956	0.983	Good	PCC Pavement			
20307	0.961	0.947	0.958	Good	PCC Pavement			
19515	0.883	0.990	0.904	Average	PCC Pavement			
19394	0.682	0.978	0.741	Poor	PCC Pavement			
97	0.857	0.990	0.884	Good	PCC Pavement			
19	0.838	0.993	0.869	Good	PCC Pavement			
22	0.956	0.952	0.955	Good	PCC Pavement			
160	0.653	0.934	0.709	Average	PCC Pavement			
40	0.707	0.724	0.710	Average	PCC Pavement			
18	0.778	0.877	0.798	Poor	PCC Pavement			
96	0.542	1.000	0.634	Poor	PCC Pavement			

Table 3. Florida Projects by DOT Rating (Using all test results)

Project	PPFq	PPFd	PPF	DOT Rating	Type Project	Avg.PPFq	Avg.PPFd	Avg.PPF
21089615201	1.000	0.942	0.988	Good	ACC Pavement			
20823515201	0.950	1.000	0.960	Good	ACC Pavement			
21330015201	0.819	0.979	0.851	Good	ACC Pavement			
20840815201	0.730	0.996	0.783	Good	ACC Pavement			
20777915201	1.000	0.979	0.996	Good	ACC Pavement			
21080015201	0.990	0.952	0.982	Good	ACC Pavement			
38020-3526	1.000	0.971	0.994	Good	ACC Pavement	0.914	0.974	0.926
21002015201	0.799	0.887	0.817	Good	ACC Pavement			
21042915201 &	0.988	1.000	0.990	Good	ACC Pavement			
21207815201	0.847	0.981	0.874	Good	Bridge			
21137315201	0.950	0.985	0.957	Good	Bridge			
50020-3524	0.893	0.997	0.914	Good	Bridge			
21042915201	0.989	0.995	0.990	Good	Pipe			
20839115201 &	0.840	0.975	0.867	Good	Combination (B/A)			
20837015201								
21063815201	0.896	0.998	0.916	Average	Bridge	0.896	0.998	0.916
20936315201	0.684	0.979	0.743	Below Avg.	Combination (B/A)	0.684	0.979	0.743

Table 4. All Florida Projects (Using all items)

Project	PPFq	PPFd	PPF	DOT Rating	Type Project	Avg.PPFq	Avg.PPFd	Avg.PPF
21089615201	1.000	0.942	0.988		ACC Pavement			
20823515201	0.950	1.000	0.960		ACC Pavement			
21063815201	0.896	0.998	0.916		Bridge			
21207815201	0.847	0.981	0.874		Bridge			
21330015201	0.819	0.979	0.851		ACC Pavement			
20840815201	0.730	0.996	0.783		ACC Pavement			
20839115201 &	0.840	0.975	0.867		Combination (B/A)			
20777915201	1.000	0.979	0.996		ACC Pavement	0.898	0.976	0.914
21137315201	0.950	0.985	0.957		Bridge			
21080015201	0.990	0.952	0.982		ACC Pavement			
50020-3524	0.893	0.997	0.914		Bridge			
38020-3526	1.000	0.971	0.994		ACC Pavement			
20936315201	0.684	0.979	0.743		Combination (B/A)			
21042915201	0.989	0.995	0.990		Pipe			
21002015201	0.799	0.887	0.817		ACC Pavement			
21042915201 &	0.988	1.000	0.990		ACC Pavement			
2123875201								

Table 5. Florida Projects by Project Type (Using Major Items Method)

Project	**PPFq**	**PPFd**	**PPF**	**DOT Rating**	**Type Project**	**Avg.PPFq**	**Avg.PPFd**	**Avg.PPF**
21089615201	1.000	0.821	0.964	Good	ACC Pavement			
20823515201	0.950	1.000	0.960	Good	ACC Pavement			
21330015201	0.819	0.952	0.846	Good	ACC Pavement			
20840815201	0.730	0.993	0.783	Good	ACC Pavement			
20777915201	1.000	0.969	0.994	Good	ACC Pavement	0.920	0.937	0.923
21080015201	0.990	0.885	0.969	Good	ACC Pavement			
38020-3526	1.000	0.968	0.994	Good	ACC Pavement			
21002015201	0.799	0.846	0.808	Good	ACC Pavement			
21042915201 &	0.988	1.000	0.990	Good	ACC Pavement			
2123875201								
21063815201	0.896	1.000	0.917	Average	Bridge			
21207815201	0.847	0.946	0.867	Good	Bridge	0.897	0.979	0.913
21137315201	0.950	0.980	0.956	Good	Bridge			
50020-3524	0.893	0.988	0.912	Good	Bridge			
20936315201	0.684	0.884	0.724	Below Avg.	Combination (B/A)			
20839115201 &	0.840	0.975	0.867	Good	Combination (B/A)	0.762	0.930	0.796
20837015201								

Table 6. Florida Projects by Project Type (Using all test results)

Project	**PPFq**	**PPFd**	**PPF**	**DOT Rating**	**Type Project**	**Avg.PPFq**	**Avg.PPFd**	**Avg.PPF**
21089615201	1.000	0.942	0.988	Good	ACC Pavement			
20823515201	0.950	1.000	0.960	Good	ACC Pavement			
21330015201	0.819	0.979	0.851	Good	ACC Pavement			
20840815201	0.730	0.996	0.783	Good	ACC Pavement			
20777915201	1.000	0.979	0.996	Good	ACC Pavement	0.920	0.967	0.929
21080015201	0.990	0.952	0.982	Good	ACC Pavement			
38020-3526	1.000	0.971	0.994	Good	ACC Pavement			
21002015201	0.799	0.887	0.817	Good	ACC Pavement			
21042915201 &	0.988	1.000	0.990	Good	ACC Pavement			
2123875201								
21063815201	0.896	0.998	0.916	Average	Bridge			
21207815201	0.847	0.981	0.874	Good	Bridge			
21137315201	0.950	0.985	0.957	Good	Bridge	0.897	0.990	0.915
50020-3524	0.893	0.997	0.914	Good	Bridge			
20936315201	0.684	0.979	0.743	Below Avg.	Combination (B/A)			
20839115201 &	0.840	0.975	0.867	Good	Combination	0.762	0.977	0.805
20837015201								
21042915201	0.989	0.995	0.990	Good	Pipe	0.989	0.995	0.990

Figure 2. Florida Projects – Evaluation Results v Test Results

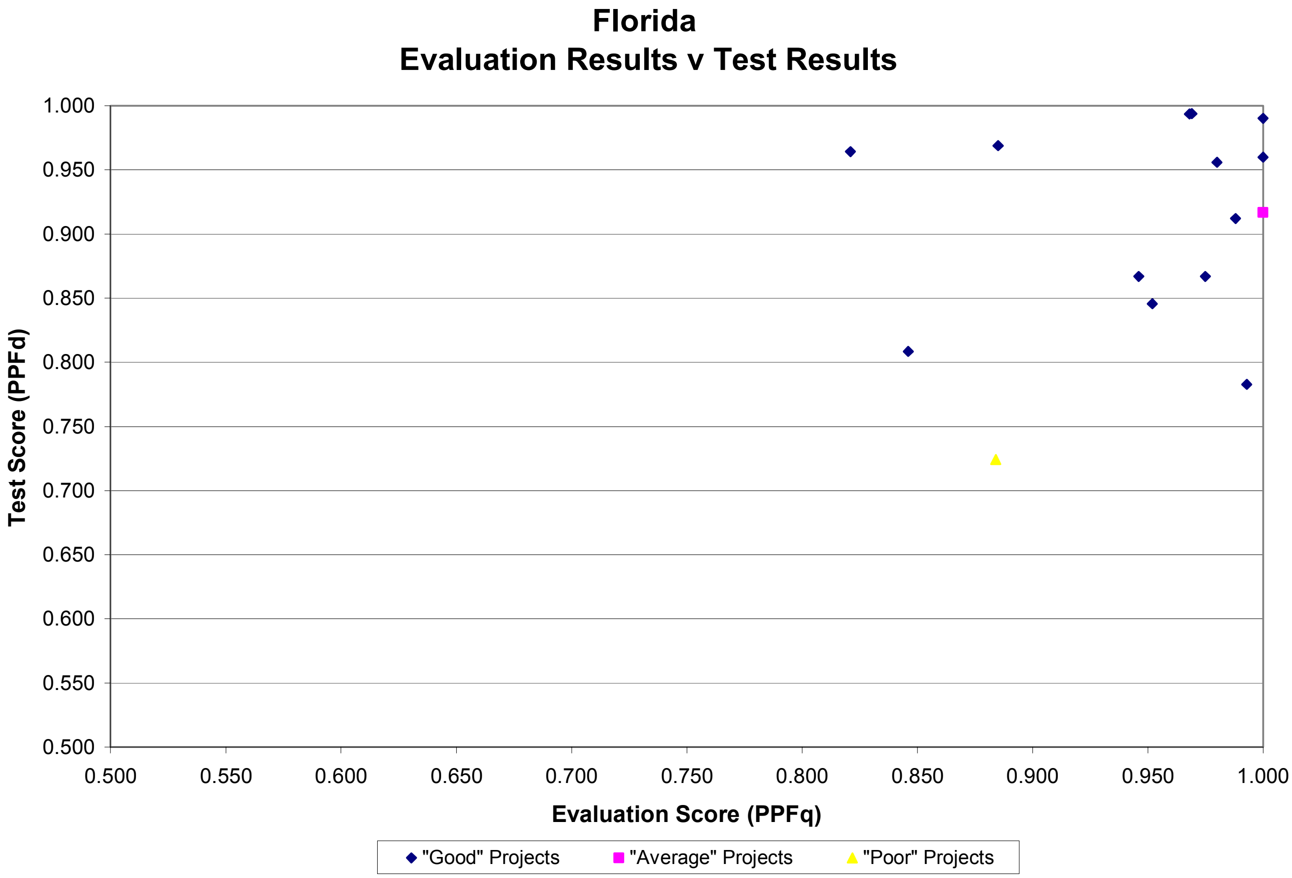


Table 7. Florida Projects by DOT Rating (Using Major Items Method)

<u>Project</u>	<u>PPFq</u>	<u>PPFd</u>	<u>PPF</u>	<u>DOT Rating</u>	<u>Type Project</u>	<u>Avg.PPFq</u>	<u>Avg.PPFd</u>	<u>Avg.PPF</u>
21089615201	1.000	0.821	0.964	Good	ACC Pavement			
20823515201	0.950	1.000	0.960	Good	ACC Pavement			
21207815201	0.847	0.946	0.867	Good	Bridge			
21330015201	0.819	0.952	0.846	Good	ACC Pavement			
20840815201	0.730	0.993	0.783	Good	ACC Pavement			
20839115201 &	0.840	0.975	0.867	Good	Combination (B/A)			
20777915201	1.000	0.969	0.994	Good	ACC Pavement	0.908	0.948	0.916
21137315201	0.950	0.980	0.956	Good	Bridge			
21080015201	0.990	0.885	0.969	Good	ACC Pavement			
50020-3524	0.893	0.988	0.912	Good	Bridge			
38020-3526	1.000	0.968	0.994	Good	ACC Pavement			
21002015201	0.799	0.846	0.808	Good	ACC Pavement			
21042915201 &	0.988	1.000	0.990	Good	ACC Pavement			
2123875201								
21063815201	0.896	1.000	0.917	Average	Bridge	0.896	1.000	0.917
20936315201	0.684	0.884	0.724	Below Avg.	Combination (B/A)	0.684	0.884	0.724

Table 8. All Florida Projects (Using Major Items Method)

Project	PPFq	PPFd	PPF	DOT Rating	Type Project	Avg.PPFq	Avg.PPFd	Avg.PPF
21089615201	1.000	0.821	0.964	Good	ACC Pavement			
20823515201	0.950	1.000	0.960	Good	ACC Pavement			
21063815201	0.896	1.000	0.917	Average	Bridge			
21207815201	0.847	0.946	0.867	Good	Bridge			
21330015201	0.819	0.952	0.846	Good	ACC Pavement			
20840815201	0.730	0.993	0.783	Good	ACC Pavement			
20839115201 &	0.840	0.975	0.867	Good	Combination (B/A)			
20777915201	1.000	0.969	0.994	Good	ACC Pavement	0.892	0.947	0.903
21137315201	0.950	0.980	0.956	Good	Bridge			
21080015201	0.990	0.885	0.969	Good	ACC Pavement			
50020-3524	0.893	0.988	0.912	Good	Bridge			
38020-3526	1.000	0.968	0.994	Good	ACC Pavement			
20936315201	0.684	0.884	0.724	Below Avg.	Combination (B/A)			
21002015201	0.799	0.846	0.808	Good	ACC Pavement			
21042915201 & 2123875201	0.988	1.000	0.990	Good	ACC Pavement			

Table 9. Iowa Projects by DOT Rating

Project	PPFq	PPFd	PPF	DOT Rating	Type Project	Avg.PPFq	Avg.PPFd	Avg.PPF
97	0.857	0.990	0.884	Good	PCC Pavement			
19	0.838	0.993	0.869	Good	PCC Pavement	0.884	0.978	0.903
22	0.956	0.952	0.955	Good	PCC Pavement			
160	0.653	0.934	0.709	Average	PCC Pavement	0.680	0.829	0.710
40	0.707	0.724	0.710	Average	PCC Pavement			
18	0.778	0.877	0.798	Poor	PCC Pavement	0.660	0.939	0.716
96	0.542	1.000	0.634	Poor	PCC Pavement			

Table 10. All Iowa Projects

Project	PPFq	PPFd	PPF	DOT Rating	Type Project	Avg.PPFq	Avg.PPFd	Avg.PPF
97	0.857	0.990	0.884	Good	PCC Pavement			
19	0.838	0.993	0.869	Good	PCC Pavement			
22	0.956	0.952	0.955	Good	PCC Pavement			
160	0.653	0.934	0.709	Average	PCC Pavement	0.762	0.924	0.794
40	0.707	0.724	0.710	Average	PCC Pavement			
18	0.778	0.877	0.798	Poor	PCC Pavement			
96	0.542	1.000	0.634	Poor	PCC Pavement			

Figure 3. Iowa Projects – Evaluation Results v Test Results

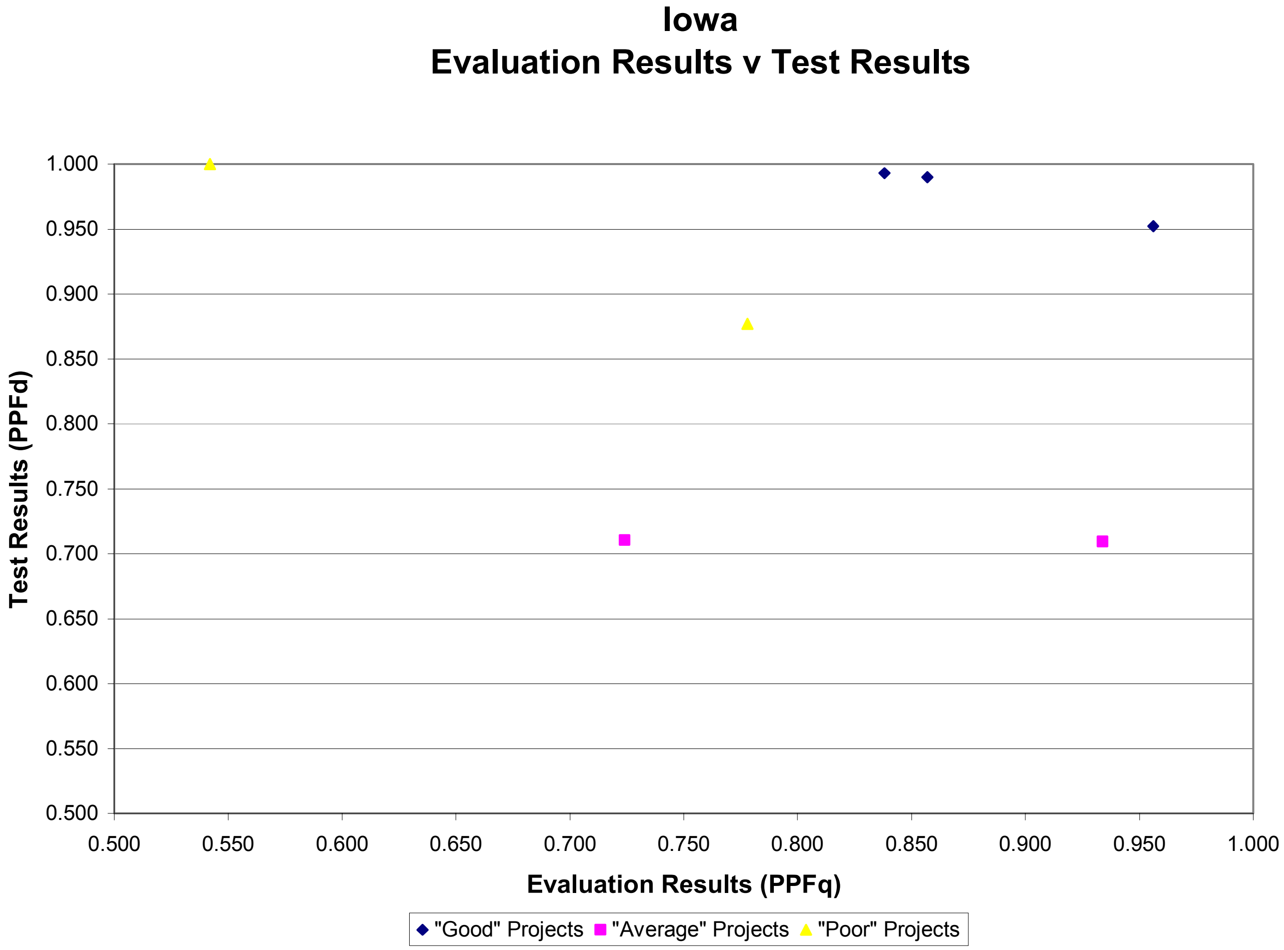


Table 10. Indiana Projects by Project Type

Project	PPFq	PPFd	PPF	DOT Rating	Type Project	Avg.PPFq	Avg.PPFd	Avg.PPF
19351	0.990	0.921	0.976	Good	ACC Pavement			
22925	0.920	0.773	0.891	Good	ACC Pavement			
21969	0.702	0.828	0.727	Average	ACC Pavement			
22677	0.964	0.980	0.967	Good	ACC Pavement	0.856	0.853	0.855
22967	0.840	0.960	0.864	Good	ACC Pavement			
23391	0.718	0.655	0.705	Average	ACC Pavement			
20961	0.694	1.000	0.755	Good	PCC Pavement			
23391	0.718	1.000	0.774	Average	PCC Pavement			
23060	0.990	0.956	0.983	Good	PCC Pavement			
20307	0.961	0.947	0.958	Good	PCC Pavement	0.821	0.979	0.853
19515	0.883	0.990	0.904	Average	PCC Pavement			
19394	0.682	0.978	0.741	Poor	PCC Pavement			

Figure 4. Indiana Projects – Evaluation Results v Test Results

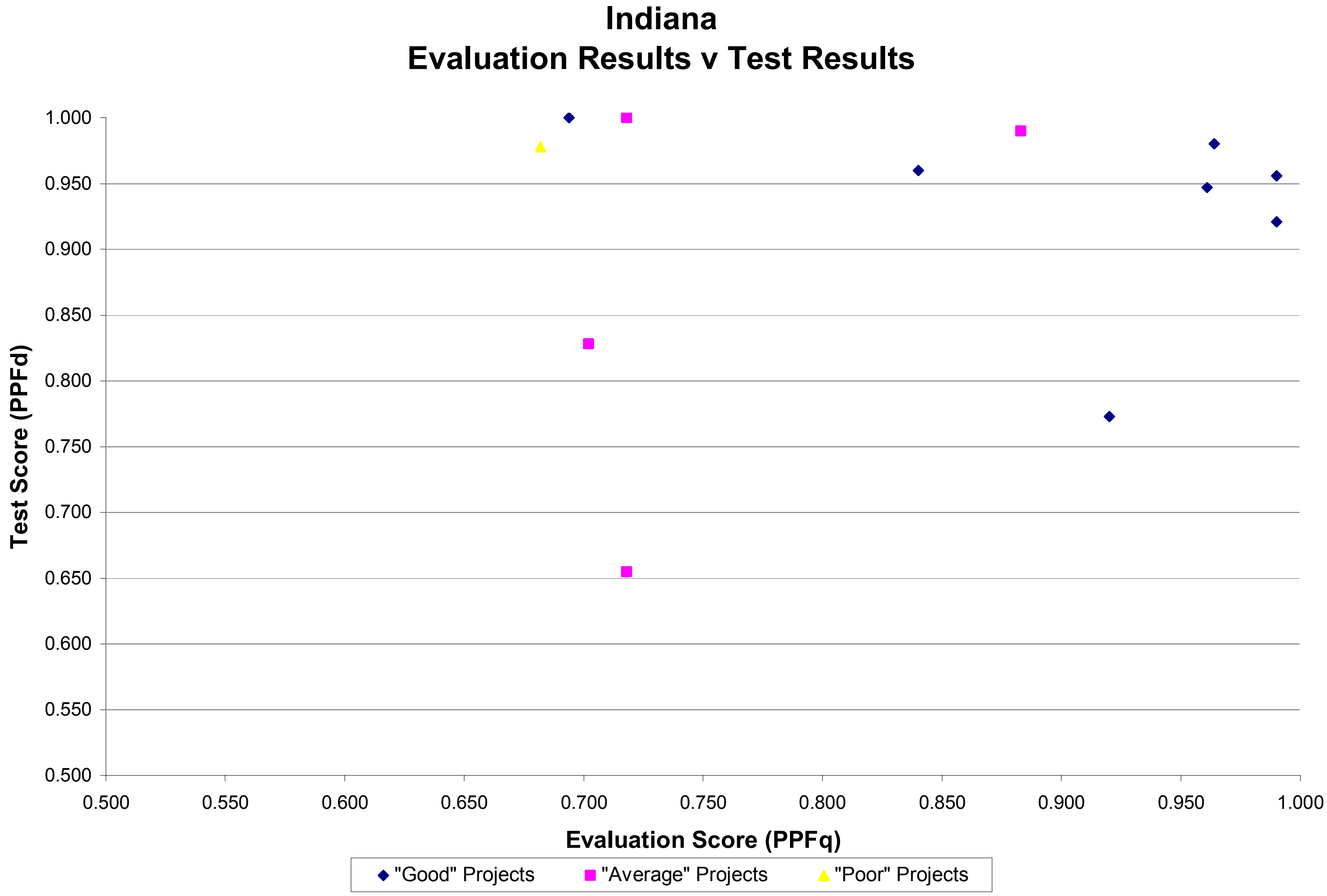


Table 11. Indiana Projects by DOT Rating

Project	PPFq	PPFd	PPF	DOT Rating	Type Project	Avg.PPFq	Avg.PPFd	Avg.PPF
19351	0.990	0.921	0.976	Good	ACC Pavement			
22925	0.920	0.773	0.891	Good	ACC Pavement			
20961	0.694	1.000	0.755	Good	PCC Pavement			
22677	0.964	0.980	0.967	Good	ACC Pavement	0.908	0.934	0.914
22967	0.840	0.960	0.864	Good	ACC Pavement			
23060	0.990	0.956	0.983	Good	PCC Pavement			
20307	0.961	0.947	0.958	Good	PCC Pavement			
23391	0.718	1.000	0.774	Average	PCC Pavement			
21969	0.702	0.828	0.727	Average	ACC Pavement	0.755	0.868	0.778
23391	0.718	0.655	0.705	Average	ACC Pavement			
19515	0.883	0.990	0.904	Average	PCC Pavement			
19394	0.682	0.978	0.741	Poor	PCC Pavement	0.682	0.978	0.741

Table 12. All Indiana Projects

Project	PPFq	PPFd	PPF	DOT Rating	Type Project	Avg.PPFq	Avg.PPFd	Avg.PPF
19351	0.990	0.921	0.976	Good	ACC Pavement			
22925	0.920	0.773	0.891	Good	ACC Pavement			
21969	0.702	0.828	0.727	Average	ACC Pavement			
22677	0.964	0.980	0.967	Good	ACC Pavement			
22967	0.840	0.960	0.864	Good	ACC Pavement			
23391	0.718	0.655	0.705	Average	ACC Pavement	0.839	0.916	0.854
20961	0.694	1.000	0.755	Good	PCC Pavement			
23391	0.718	1.000	0.774	Average	PCC Pavement			
23060	0.990	0.956	0.983	Good	PCC Pavement			
20307	0.961	0.947	0.958	Good	PCC Pavement			
19515	0.883	0.990	0.904	Average	PCC Pavement			
19394	0.682	0.978	0.741	Poor	PCC Pavement			

Figure 5. Pennsylvania Projects – Evaluation Results v Test Results

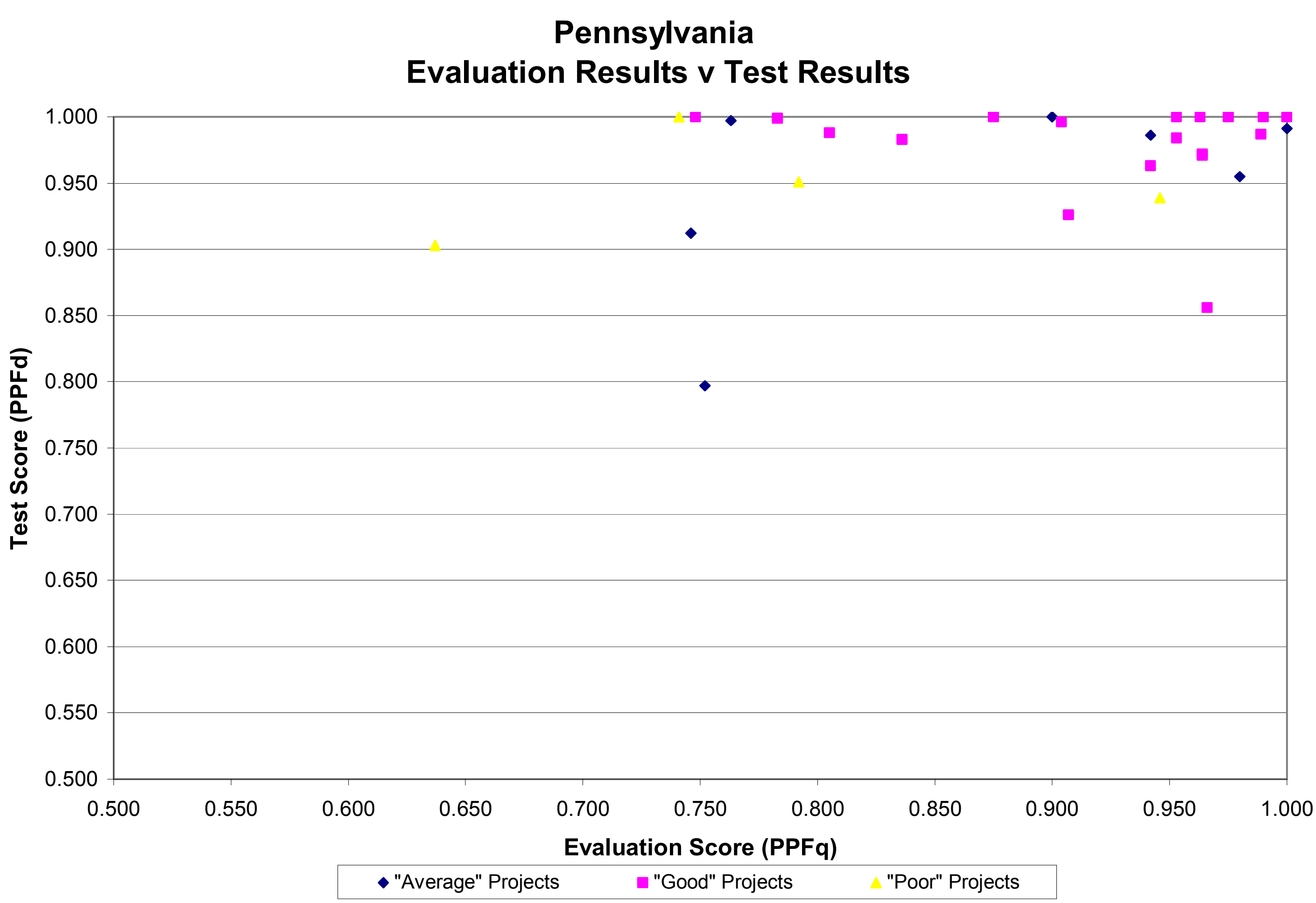


Table 13. Pennsylvania Projects by District

Project	District	PPFq	PPFd	PPF	DOT Rating	Avg. PPFq	Avg. PPFd	Avg. PPF
O21115	2	0.966	0.856	0.944	Good			
O22142	2	1.000	1.000	1.000	Average			
O27051	2	0.748	1.000	0.798	Good	0.894	0.929	0.901
O21118	2	0.752	0.797	0.761	Average			
O25070	2	0.946	0.939	0.945	Poor			
O22143	2	0.907	0.926	0.911	Good			
O23029	2	0.942	0.986	0.951	Average			
O42259	4	0.637	0.903	0.690	Poor			
6006 - #1	4	0.763	0.997	0.810	Average	0.760	0.968	0.802
6006 - PS2	4	0.805	0.988	0.842	Good			
O43228	4	0.836	0.983	0.865	Good			
SR 191-02B	5	0.792	0.951	0.824	Poor			
SR 78-029	5	0.980	0.955	0.975	Average	0.892	0.967	0.907
O54059	5	0.904	0.996	0.922	Good			
O91092	9	0.989	0.987	0.989	Good			
O91040	9	0.953	0.984	0.959	Good			
O91086	9	1.000	1.000	1.000	Good			
O91602	9	0.953	1.000	0.962	Good			
O91701	9	0.990	1.000	0.992	Good			
O91710	9	0.975	1.000	0.980	Good	0.935	0.986	0.945
O92081	9	0.783	0.999	0.826	Good			
O92086	9	1.000	0.991	0.998	Average			
O92101	9	0.875	1.000	0.900	Good			
O91065	9	0.964	0.972	0.966	Good			
O91716	9	0.963	1.000	0.970	Good			
O95023	9	0.964	0.971	0.965	Good			
O93131	9	0.746	0.912	0.779	Average			
104165	10	0.741	1.000	0.793	Poor			
102144	10	0.900	1.000	0.920	Average	0.861	0.988	0.886
103069	10	0.942	0.963	0.946	Good			

Table 14. Pennsylvania Projects by Project Type

Project	District	PPFq	PPFd	PPF	Type Project	Avg. PPFq	Avg. PPFd	Avg. PPF
O21115	2	0.966	0.856	0.944	ACC Pavement			
O22142	2	1.000	1.000	1.000	ACC Pavement			
O21118	2	0.752	0.797	0.761	ACC Pavement			
O25070	2	0.946	0.939	0.945	ACC Pavement			
O22143	2	0.907	0.926	0.911	ACC Pavement			
O42259	4	0.637	0.903	0.690	ACC Pavement			
SR 78-029	5	0.980	0.955	0.975	ACC Pavement			
O91602	9	0.953	1.000	0.962	ACC Pavement			
O91701	9	0.990	1.000	0.992	ACC Pavement	0.915	0.957	0.923
O91710	9	0.975	1.000	0.980	ACC Pavement			
O92086	9	1.000	0.991	0.998	ACC Pavement			
O92101	9	0.875	1.000	0.900	ACC Pavement			
O91065	9	0.964	0.972	0.966	ACC Pavement			
O91716	9	0.963	1.000	0.970	ACC Pavement			
O95023	9	0.964	0.971	0.965	ACC Pavement			
104165	10	0.741	1.000	0.793	ACC Pavement			
103069	10	0.942	0.963	0.946	ACC Pavement			
SR 191-02B	5	0.792	0.951	0.824	Bridge			
O91040	9	0.953	0.984	0.959	Bridge			
O91086	9	1.000	1.000	1.000	Bridge	0.886	0.987	0.906
O92081	9	0.783	0.999	0.826	Bridge			
102144	10	0.900	1.000	0.920	Bridge			
O27051	2	0.748	1.000	0.798	Combination (B/A)	0.869	0.994	0.894
O91092	9	0.989	0.987	0.989	Combination (B/A)			
O23029	2	0.942	0.986	0.951	PCC Pavement			
6006 - #1	4	0.763	0.997	0.810	PCC Pavement			
6006 - PS2	4	0.805	0.988	0.842	PCC Pavement			
O43228	4	0.836	0.983	0.865	PCC Pavement	0.833	0.977	0.862
O54059	5	0.904	0.996	0.922	PCC Pavement			
O93131	9	0.746	0.912	0.779	PCC Pavement			

Table 15. Pennsylvania Projects by DOT Rating

Project	District	PPFq	PPFd	PPF	DOT Rating	Avg. PPFq	Avg. PPFd	Avg. PPF
O22142	2	1.000	1.000	1.000	Average			
O21118	2	0.752	0.797	0.761	Average			
SR 78-029	5	0.980	0.955	0.975	Average			
O92086	9	1.000	0.991	0.998	Average			
102144	10	0.900	1.000	0.920	Average	0.885	0.955	0.899
O23029	2	0.942	0.986	0.951	Average			
6006 - #1	4	0.763	0.997	0.810	Average			
O93131	9	0.746	0.912	0.779	Average			
O21115	2	0.966	0.856	0.944	Good			
O22143	2	0.907	0.926	0.911	Good			
O91602	9	0.953	1.000	0.962	Good			
O91701	9	0.990	1.000	0.992	Good			
O91710	9	0.975	1.000	0.980	Good			
O92101	9	0.875	1.000	0.900	Good			
O91065	9	0.964	0.972	0.966	Good			
O91716	9	0.963	1.000	0.970	Good			
O95023	9	0.964	0.971	0.965	Good	0.918	0.979	0.930
103069	10	0.942	0.963	0.946	Good			
O91040	9	0.953	0.984	0.959	Good			
O91086	9	1.000	1.000	1.000	Good			
O92081	9	0.783	0.999	0.826	Good			
O27051	2	0.748	1.000	0.798	Good			
O91092	9	0.989	0.987	0.989	Good			
6006 - PS2	4	0.805	0.988	0.842	Good			
O43228	4	0.836	0.983	0.865	Good			
O54059	5	0.904	0.996	0.922	Good			
O25070	2	0.946	0.939	0.945	Poor			
O42259	4	0.637	0.903	0.690	Poor	0.779	0.948	0.813
104165	10	0.741	1.000	0.793	Poor			
SR 191-02B	5	0.792	0.951	0.824	Poor			

Table 16. Pennsylvania Projects by DOT Rating - "Chosen Contractor" v Other Contractors

Project	PPFq	PPFd	PPF	DOT Rating	Chosen Contractor?	Good/Poor/ Average	Avg. PPFq	Avg. PPFd	Avg. PPF
O21118	0.752	0.797	0.761	Average	No				
SR 78-029	0.980	0.955	0.975	Average	No				
102144	0.900	1.000	0.920	Average	No	**Average**	0.849	0.937	0.866
6006 - #1	0.763	0.997	0.810	Average	No				
O22143	0.907	0.926	0.911	Good	No				
103069	0.942	0.963	0.946	Good	No	**Good**	0.895	0.957	0.907
O43228	0.836	0.983	0.865	Good	No				
O25070	0.946	0.939	0.945	Poor	No				
O42259	0.637	0.903	0.690	Poor	No	**Poor**	0.779	0.948	0.813
104165	0.741	1.000	0.793	Poor	No				
SR 191-02B	0.792	0.951	0.824	Poor	No				
O22142	1.000	1.000	1.000	Average	Yes				
O92086	1.000	0.991	0.998	Average	Yes	**Average**	0.922	0.972	0.932
O23029	0.942	0.986	0.951	Average	Yes				
O93131	0.746	0.912	0.779	Average	Yes				
O21115	0.966	0.856	0.944	Good	Yes				
O91602	0.953	1.000	0.962	Good	Yes				
O91701	0.990	1.000	0.992	Good	Yes				
O91710	0.975	1.000	0.980	Good	Yes				
O92101	0.875	1.000	0.900	Good	Yes				
O91065	0.964	0.972	0.966	Good	Yes				
O91716	0.963	1.000	0.970	Good	Yes	**Good**	0.922	0.984	0.934
O95023	0.964	0.971	0.965	Good	Yes				
O91040	0.953	0.984	0.959	Good	Yes				
O91086	1.000	1.000	1.000	Good	Yes				
O92081	0.783	0.999	0.826	Good	Yes				
O27051	0.748	1.000	0.798	Good	Yes				
O91092	0.989	0.987	0.989	Good	Yes				
6006 - PS2	0.805	0.988	0.842	Good	Yes				
O54059	0.904	0.996	0.922	Good	Yes				

Table 17. Pennsylvania Projects by "Chosen Contractor" v Other Contractors

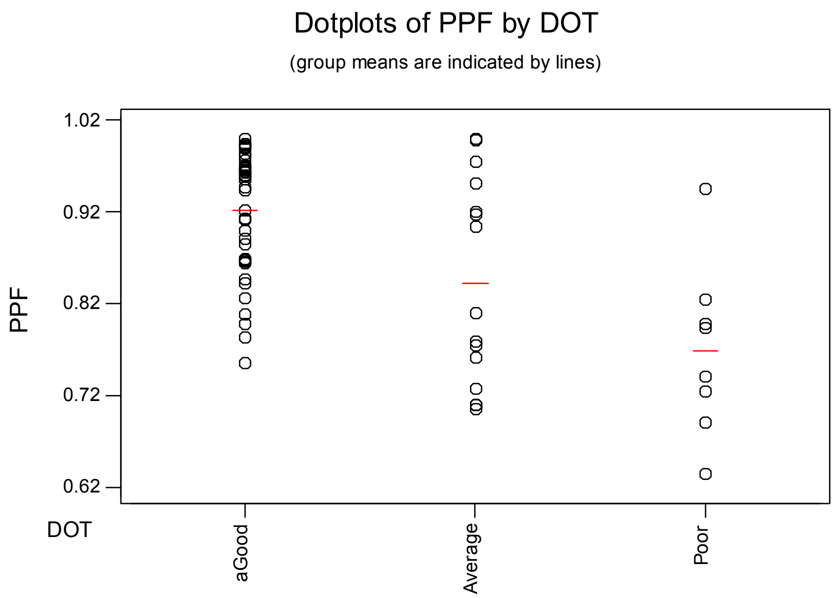
Project	PPFq	PPFd	PPF	DOT Rating	Chosen Contractor?	Avg. PPFq	Avg. PPFd	Avg. PPF
O21118	0.752	0.797	0.761	Average	No			
SR 78-029	0.980	0.955	0.975	Average	No			
102144	0.900	1.000	0.920	Average	No			
6006 - #1	0.763	0.997	0.810	Average	No			
O22143	0.907	0.926	0.911	Good	No			
103069	0.942	0.963	0.946	Good	No	0.836	0.947	0.858
O43228	0.836	0.983	0.865	Good	No			
O25070	0.946	0.939	0.945	Poor	No			
O42259	0.637	0.903	0.690	Poor	No			
104165	0.741	1.000	0.793	Poor	No			
SR 191-02B	0.792	0.951	0.824	Poor	No			
O22142	1.000	1.000	1.000	Average	Yes			
O92086	1.000	0.991	0.998	Average	Yes			
O23029	0.942	0.986	0.951	Average	Yes			
O93131	0.746	0.912	0.779	Average	Yes			
O21115	0.966	0.856	0.944	Good	Yes			
O91602	0.953	1.000	0.962	Good	Yes			
O91701	0.990	1.000	0.992	Good	Yes	0.922	0.981	0.934
O91710	0.975	1.000	0.980	Good	Yes			
O92101	0.875	1.000	0.900	Good	Yes			
O91065	0.964	0.972	0.966	Good	Yes			
O91716	0.963	1.000	0.970	Good	Yes			
O95023	0.964	0.971	0.965	Good	Yes			
O91040	0.953	0.984	0.959	Good	Yes			
O91086	1.000	1.000	1.000	Good	Yes			
O92081	0.783	0.999	0.826	Good	Yes			
O27051	0.748	1.000	0.798	Good	Yes			
O91092	0.989	0.987	0.989	Good	Yes			
6006 - PS2	0.805	0.988	0.842	Good	Yes			
O54059	0.904	0.996	0.922	Good	Yes			
					All Projects	0.891	0.969	0.906

Table 18. Contractor Factor (CF) – Pennsylvania's "Chosen Contractor"

Project	District	PPFq	PPFd	PPF	DOT Rating	Type Project		
O22142	2	1.000	1.000	1.000	Average	ACC Pavement		
O92086	9	1.000	0.991	0.998	Average	ACC Pavement		
O23029	2	0.942	0.986	0.951	Average	PCC Pavement		
O93131	9	0.746	0.912	0.779	Average	PCC Pavement		
O21115	2	0.966	0.856	0.944	Good	ACC Pavement		
O91602	9	0.953	1.000	0.962	Good	ACC Pavement		
O91701	9	0.990	1.000	0.992	Good	ACC Pavement		
O91710	9	0.975	1.000	0.980	Good	ACC Pavement		
O92101	9	0.875	1.000	0.900	Good	ACC Pavement	**CF =**	0.934
O91065	9	0.964	0.972	0.966	Good	ACC Pavement		
O91716	9	0.963	1.000	0.970	Good	ACC Pavement		
O95023	9	0.964	0.971	0.965	Good	ACC Pavement		
O91040	9	0.953	0.984	0.959	Good	Bridge		
O91086	9	1.000	1.000	1.000	Good	Bridge		
O92081	9	0.783	0.999	0.826	Good	Bridge		
O27051	2	0.748	1.000	0.798	Good	Combination (B/A)		
O91092	9	0.989	0.987	0.989	Good	Combination (B/A)		
6006 - PS2	4	0.805	0.988	0.842	Good	PCC Pavement		
O54059	5	0.904	0.996	0.922	Good	PCC Pavement		

APPENDIX D

STATISTICAL ANALYSIS



Dotplots of PPF by DOT
(group means are indicated by lines)
1.02
0.92
0.82
0.72
0.62
PPF
DOT
aGood
Average
Poor

ALLSTATE ANALYSIS

One-way Analysis of Variance

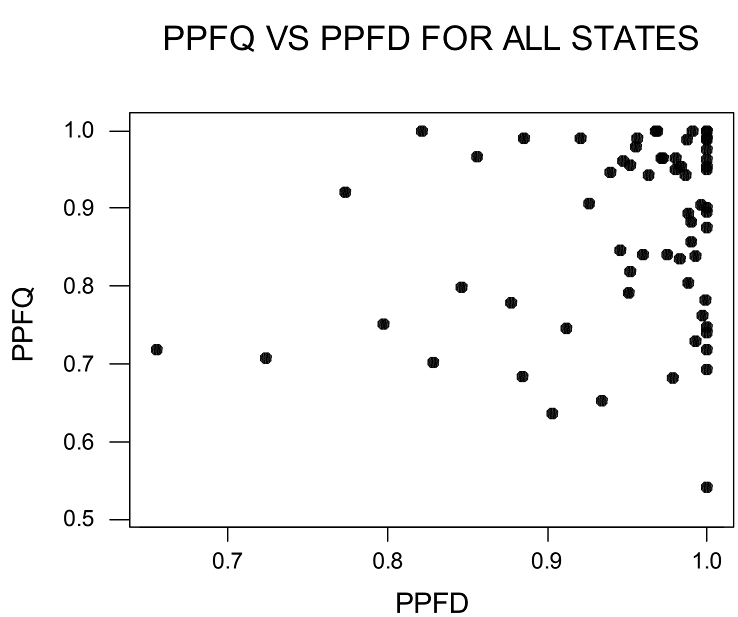
```
Analysis of Variance for PPF
Source     DF        SS        MS        F        P
DOT         2   0.18734   0.09367    13.69    0.000
Error      61   0.41745   0.00684
Total      63   0.60479
                                   Individual 95% CIs For Mean
                                   Based on Pooled StDev
Level       N      Mean     StDev  ---------+---------+---------+------
-
aGood      41   0.92071   0.06653                            (---*--)
Average    15   0.84267   0.11266                (-----*-----)
Poor        8   0.76863   0.09464  (---------*--------)
                                   ---------+---------+---------+------
-
Pooled StDev =  0.08272                 0.770     0.840     0.910

Tukey's pairwise comparisons

    Family error rate = 0.0500
Individual error rate = 0.0193

Critical value = 3.40

Intervals for (column level mean) - (row level mean)

           aGood       Average

 Average     0.01803
             0.13806

 Poor        0.07521    -0.01303
             0.22895     0.16111
```

One-way Analysis of Variance

```
Analysis of Variance for PPFQ
Source     DF        SS        MS        F        P
DOT         2   0.26628   0.13314    13.65    0.000
Error      61   0.59491   0.00975
Total      63   0.86119
                                   Individual 95% CIs For Mean
                                   Based on Pooled StDev
Level       N      Mean     StDev  ---------+---------+---------+------
-
aGood      41   0.91056   0.08424                               (---*--
-)
Average    15   0.82400   0.12245                 (-----*------)
Poor        8   0.72525   0.12021   (--------*--------)
                                   ---------+---------+---------+------
-
Pooled StDev =  0.09876                  0.720     0.800     0.880

Tukey's pairwise comparisons

    Family error rate = 0.0500
Individual error rate = 0.0193

Critical value = 3.40

Intervals for (column level mean) - (row level mean)

           aGood       Average

 Average     0.01492
             0.15821

 Poor        0.09354    -0.00519
             0.27708     0.20269
```

One-way Analysis of Variance

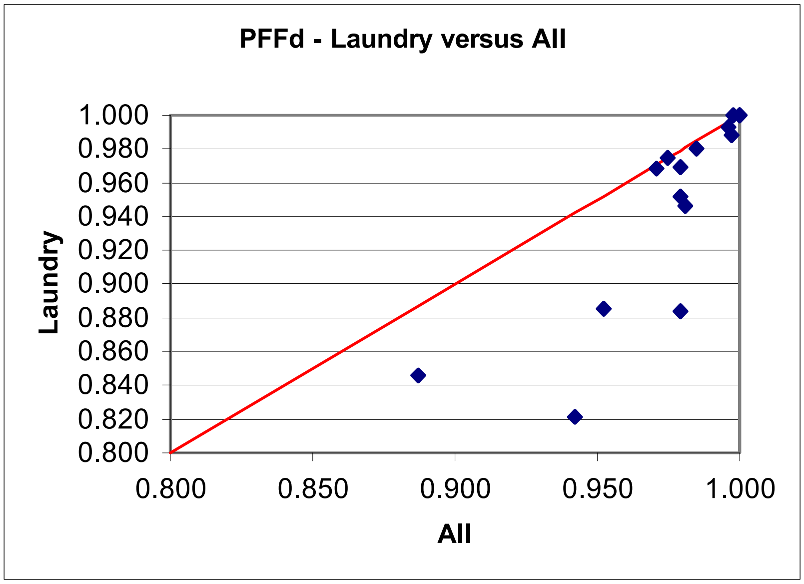
```
Analysis of Variance for PPFD
Source     DF        SS        MS        F        P
DOT         2   0.02129   0.01065     2.09    0.132
Error      61   0.31027   0.00509
Total      63   0.33156
                                   Individual 95% CIs For Mean
                                   Based on Pooled StDev
Level       N      Mean     StDev  -------+---------+---------+--------
-
aGood      41   0.96146   0.05328                      (------*-------)
Average    15   0.91793   0.11323   (-----------*-----------)
Poor        8   0.94150   0.04960      (----------------*--------------
--)
                                   -------+---------+---------+--------
-
Pooled StDev =  0.07132                 0.900     0.930     0.960

Tukey's pairwise comparisons

    Family error rate = 0.0500
Individual error rate = 0.0193

Critical value = 3.40

Intervals for (column level mean) - (row level mean)

           aGood       Average

 Average    -0.00821
             0.09527

 Poor       -0.04631    -0.09863
             0.08624     0.05150
```



r=.235 p=.062

Florida PPFd (All versus Laundry)

All	Laundry
0.800	
0.887	0.846
0.942	0.821
0.952	0.885
0.971	0.968
0.975	0.975
0.979	0.952
0.979	0.969
0.979	0.884
0.981	0.946
0.985	0.980
0.996	0.993
0.997	0.988
0.998	1.000
1.000	1.000
1.000	1.000



t-Test: Paired Two Sample for Means

	Variable 1	*Variable 2*
Mean	0.97473333	0.947133333
Variance	0.00087607	0.003495552
Observations	15	15
Pearson Correlation	0.82881935	
Hypothesized Mean Difference	0	
df	14	
t Stat	2.78723562	
P(T<=t) one-tail	0.00727049	
t Critical one-tail	1.76130925	
P(T<=t) two-tail	0.01454098	
t Critical two-tail	2.1447886	

Pennsylvania Data

One-way Analysis of Variance

```
Analysis of Variance for PPF
Source     DF        SS        MS        F        P
NEWENT      1   0.03988   0.03988     6.52    0.016
Error      28   0.17136   0.00612
Total      29   0.21124
                                   Individual 95% CIs For Mean
                                   Based on Pooled StDev
Level       N      Mean     StDev  ---------+---------+---------+------
-
No         11   0.85818   0.09001   (---------*--------)
Yes        19   0.93384   0.07084                    (-------*------)
                                   ---------+---------+---------+------
-
Pooled StDev =  0.07823                 0.850     0.900     0.950

Tukey's pairwise comparisons

    Family error rate = 0.0500
Individual error rate = 0.0500

Critical value = 2.90

Intervals for (column level mean) - (row level mean)

               No

     Yes    -0.13637
            -0.01495
```

One-way Analysis of Variance

```
Analysis of Variance for PPF
Source     DF        SS        MS        F        P
DISTRICT    4   0.06463   0.01616     2.76    0.050
Error      25   0.14661   0.00586
Total      29   0.21124
                                   Individual 95% CIs For Mean
                                   Based on Pooled StDev
Level       N      Mean     StDev  ----------+---------+---------+-----
-
 2          7   0.90143   0.08793                (-------*------)
 4          4   0.80175   0.07784  (---------*---------)
 5          3   0.90700   0.07661             (-----------*-----------)
 9         13   0.94508   0.06886                        (----*-----)
10          3   0.88633   0.08187          (-----------*----------)
                                   ----------+---------+---------+-----
-
Pooled StDev =  0.07658                  0.800     0.880     0.960

Tukey's pairwise comparisons

    Family error rate = 0.0500
Individual error rate = 0.00706

Critical value = 4.15
```

Intervals for (column level mean) - (row level mean)

	2	4	5	9
4	-0.04117 0.24053			
5	-0.16064 0.14950	-0.27688 0.06638		
9	-0.14900 0.06170	-0.27182 -0.01484	-0.18201 0.10586	
10	-0.13998 0.17017	-0.25622 0.08705	-0.16282 0.20415	-0.08519 0.20268

General Linear Model

Factor	Type	Levels	Values
NEWENT	fixed	2	No Yes
DISTRICT	fixed	5	2 4 5 9 10

Analysis of Variance for PPF, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
NEWENT	1	0.039881	0.006489	0.006489	1.11	0.302
DISTRICT	4	0.031241	0.031241	0.007810	1.34	0.285
Error	24	0.140121	0.140121	0.005838		
Total	29	0.211243				

Unusual Observations for PPF

Obs	PPF	Fit	StDev Fit	Residual	St Resid
27	0.77900	0.94508	0.02119	-0.16608	-2.26R

R denotes an observation with a large standardized residual.