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Through several in-depth meetings with LaDOTD officials, a template-based contract time system using 23 templates was developed that encompasses the majority of construction at LaDOTD. The final computer product delivers the 23 templates in a Windows-based environment for a personal computer. Formally checking the system's reliability and validity was beyond the scope of this research, but preliminary feedback from the users indicates the system is giving reasonable results.

The research team discovered several innovative contracting procedures that could prove beneficial to LaDOTD, including: design/build, dispute review boards, incentives/disincentives for time and quality, prequalification, and privatization. Other concepts that the LaDOTD has used in the past should continue to be used, and, when appropriate, expanded, including: performance-related specifications, value engineering, and warranties. The researchers developed detailed systems for use of dispute review boards, incentives/disincentives, prequalification, and privatization.

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LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
LOUISIANA TRANSPORTATION RESEARCH CENTER

EVALUATION OF CONTRACT TIME ESTIMATION AND CONTRACTING PROCEDURES FOR LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT CONSTRUCTION PROJECTS

FINAL REPORT
Volume I

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ABSTRACT

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IMPLEMENTATION STATEMENT

The implementation of the two sub-projects are relatively independent of each other. Sub-project A, the development of a computer-assisted contract time estimation system, can be implemented entirely within the Contracts Section of the LaDOTD. The work plan for this sub-project has included appropriate tasks to provide for system design and documentation, prototype evaluation and testing, and end-user feedback to ensure a successful operational implementation at the conclusion of the project. To support the continued successful application of the system to the contract proposal development process within the Contracts Section, the following points need to be addressed by LaDOTD:

- Contracts Section technicians need more computer terminals providing access to the new software system. Ideally, each technician should have such a computer at his/her work station.

- The Contracts Section needs to provide additional computer training for technicians who use the system to promote self-sufficiency for routine software and system maintenance tasks.

- The Computer Center needs to strengthen its support of personal computer-based interactive applications.

Sub-project B presents objective analyses of several innovative contracting concepts. Implementation of these concepts will require modification of the terms and conditions of construction contracts issued by the LaDOTD. Prior to this implementation, the proposed contract language must be reviewed by the LaDOTD staff, the state Attorney General's office and other appropriate legal review bodies. In some cases legislative action may be required to modify current state laws.

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INTRODUCTION

In the early 1990's, the Federal Highway Administration (FHWA), and the Transportation Research Board (TRB) actively researched ways of improving State DOT construction contracts. TRB published its report on *Innovative Contracting Practices* strongly urging states to consider and experiment with alternative forms of contracts. The FHWA, under Final Rule 23-CFR-635.121(a), required their approval of all techniques for contract time determination on projects using federal monies; Louisiana's method was approved in December 1991. As a result of those federal activities, the Louisiana Department of Transportation and Development (LaDOTD) instituted this study for the "Evaluation of Contract Time Estimation and Contracting Procedures for Louisiana Department of Transportation and Development Construction Projects."

Accurate and objective contract time estimation minimizes the total cost of a constructed project. Minimizing construction contract time generally minimizes construction costs. But, contract duration that is too short will increase the total cost of construction, and decrease the quality of the final product. Existing procedures for estimating contract duration, both at LaDOTD and at other State DOT's, rely heavily on the estimator's knowledge and experience of the construction process. Those procedures allow contract duration to be based on *ad hoc* and subjective techniques; the logic used is not always evident or documentable. Often the estimator may not be fully aware of the construction process. Therefore, this study develops a systematic approach to contract time estimation using computerized information system techniques.

Innovative contracting practices are designed to improve the quality of construction and to minimize costs and delays associated with construction disputes. Nearly all construction done for the public must be done under "public bid" laws, that generally require the contract to be awarded to the "lowest responsible bidder." Awarding contracts under these laws have not eliminated problems, and often create problems. The FHWA and many State DOT's are looking at ways to improve the contracting process; this study is LaDOTD's initial research into these improvements.

OBJECTIVE

The objective of this research was (1) to provide the Louisiana DOTD with a systematic approach to the determination of contract duration, and (2) to explore innovative contracting procedures that may prove beneficial in Louisiana DOTD projects.

SCOPE

These objectives will be accomplished through a series of tasks which include:

TASK 1. **Review of Literature and Survey of Current Practice**. A comprehensive literature review and survey of the states has been conducted to determine the current states of practice in contract time determination and innovative contracting procedures.

TASK 2. **Review of Current LaDOTD Practice and Procedures**. We have become familiar with the existing LaDOTD procedures, data availability, data quality, personnel, and other functional requirements which have been necessary to this effort.

TASK 3. **Examine Innovative Contracting Options**. Innovative contracting procedures and their applicability to the LaDOTD have been examined and several of the appropriate innovative concepts are recommended.

TASK 4. **System Development**. A contract duration estimation system has been developed, documented and installed in the LaDOTD Contracts and Specifications Section.

METHOD OF PROCEDURE (SUB-PROJECT A)

State-of-Practice Review

Literature Review

The literature review was the initial task pursued by the research team. This study involved contacting various organizations including Transportation Research Board (TRB), Federal Highway Administration (FHWA), Construction Industry Institute (CII), National Cooperative Highway Research Program (NCHRP), American Society of Civil Engineers (ASCE), and Associated General Contractors of America (AGC). In addition, many DOT agencies were contacted for information regarding their methods of establishing contract durations. Several of the contacted DOT agencies supplied the research team with documentation supporting their methods.

Due to the efforts performed during the literature review, much information was received regarding the current methods of estimating contract durations. Although all of the information received was helpful, the most beneficial proved to be reports from the FHWA, research efforts for Texas DOT, research efforts for Mississippi DOT, synthesis from NCHRP, and research papers published in ASCE journals.

Software Review

As part of the research, the Texas DOT computerized contract time determination system (CTDS) was reviewed. The research team also performed an analysis of commercially available project management/scheduling systems including Primavera, Microsoft Project, and Time Line.

Telephone Survey

A telephone survey of state DOT agencies was conducted by the research team. This survey was performed primarily on the southern states. The results reinforced the ideas and concepts found from the literature review.

LaDOTD Practice

An essential part of the assessment of the State-of-Practice, with respect to contract time determination, included several on-site visits to the Contracts Section of the Louisiana Department of Transportation and Development (LaDOTD). Extended interviews were conducted with each professional employee of the Section during the periods of May 26 and 27, 1994 and also June 1, 1994. Brief consultations were also held with support staff and personnel in allied areas. The interviews addressed

the contract time determination process in terms of an information flow model. Each person was requested to provide information such as; "Where does the information you receive come from?", "What processes do you use to generate the contract time for the construction proposal?", "What external resources and/or tools do you use to assist you in the determination of the contract time?", and "Who receives the output of your work?"

In the course of interviews, special attention was given to operating styles of the individuals so that the computer software to be generated would be as compatible as possible with current work patterns. In each interview, specific projects were discussed and the contract technician was encouraged to identify common assumptions that he/she made and those conditions that signaled special processing of the contract time calculation.

Following up on information received in the Contracts Section interviews led to contacts with other parts of the LaDOTD organization, including Construction Division, Contract Services, and Computer Support. Contacts with personnel in these areas ranged from minor to extensive.

Development Framework

Trial Production Rate Analysis

The proposed contract time estimating system is based on production rates for certain work items specific to a construction project. These rates need to be very explicit and must contain a high degree of reliability. However, minimal options for obtaining production rates exist. The options included soliciting construction contractors, modeling the work items, obtaining from published documents (i.e., *Means Guide*), or analyzing historical project reports. A trial study was performed by analyzing the daily reports, design plans, and any plan change information from three independent projects. The project types included in the trial study were a bridge replacement project and two asphaltic concrete overlays, all of which were from the same LaDOTD district and supervised by the same resident engineer.

Work Item Analysis

Currently, LaDOTD uses a manual method for estimating contract time that involves filling required information on a predefined contract time worksheet. These worksheets are kept for archival purposes. In an effort to analyze the consistency of occurrence of work items for specific types of construction projects, the research

team obtained approximately one-hundred active (meaning the project is currently being constructed) contract time worksheets. These worksheets were divided into their respective classification as directed by the current LaDOTD project classification scheme. Each classification was examined to determine if any substantial relationships exist between certain work items and certain project features.

Alternative Project Classification Scheme

The research team developed four alternative project classification schemes, described below:

Template Grouping 1. This classification scheme organizes LaDOTD projects by type of construction. In this grouping, "New Construction" represents all *new* construction. "Reconstruction" signifies projects where realignment, remove/replace, etc., occur, and "Rehabilitation" represents actions to restore to former capacity (grinding, seal joints, etc.). Fifteen groups were proposed:

1. New Construction - Interstate
2. New Construction - Highway
3. New Construction - Bridge
4. Reconstruction - Interstate
5. Reconstruction - Highway
6. Reconstruction - Bridge
7. Rehabilitation - Interstate
8. Rehabilitation - Highway
9. Rehabilitation - Bridge
10. Bridge Replacement - On-System
11. Bridge Replacement - Off-System
12. Overlay Only
13. Widen Only
14. Widen & Overlay
15. Miscellaneous

Template Grouping 2. This grouping scheme organizes LaDOTD projects by construction type. This template grouping is generic in that it does not separate types of projects by interstate, highway, or bridge. Consequently, in order to maintain the needed flexibility, each underlying template would be nearly identical, i.e., contain the same work items. This list is identical to the list currently used by the LaDOTD Contracts and Specifications Section.

1. New Construction
2. Reconstruction
3. Construction of Additional Lanes
4. Interstate Maintenance
5. Urban Systems
6. Bridge Replacement
7. Off-System Bridge Replacement
8. Overlay
9. Miscellaneous

Template Grouping 3. This template classification scheme is used by the Texas DOT. The scheme incorporates thirteen construction categories and five project factors that affect contract time.

The construction types are:

1. Overlay
2. Rehabilitate Existing Road
3. Convert Non-Freeway to Freeway
4. Widen Freeway
5. Widen Non-Freeway
6. New Location Freeway
7. New Location Non-Freeway
8. Interchange
9. Bridge Widening/Rehabilitation
10. Bridge Replacement

11. Upgrade Freeway to Standards

12. Upgrade Non-Freeway to Standards

13. Miscellaneous Construction

The five factors that act as modifiers to the calculated contract time are:

1. Geographic Location: Urban, Rural, Suburban

2. Quantity of Work: Large, Medium, Small

3. Traffic Conditions: High, Moderate, Light

4. Complexity: High, Medium, Low

5. Soil Conditions: Good, Fair, Poor

Template Grouping 4. This scheme, also developed by the research team, contained unique ideas and concepts specific to the classification and/or selection of project types (templates). The templates are designed to contain pertinent information (i.e., work items, overlap and concurrence, etc.) of a specific construction project (i.e., overlay, bridge replacement, new construction, etc.). This scheme required the identification of certain common features unique to a construction project. Once these features were identified, the project could be classified and/or selected. Items 1, 2, and 3 select the underlying CPM template, while items 4, 5, 6, and 7 refine the contract time estimate (or possibly the production rates).

1. Choose Finished Surface Type (select only one)

- Asphalt
- Concrete
- None
- Asphalt/Widened
- Concrete/Widened

2. Choose Existing Surface Type (select only one)

- Asphalt - Asphalt/Removed
- Concrete - Concrete/Removed
- None

3. Choose the Construction Type

(a) Road
- Number of lanes
- Linear length of project
- Divided roadway
- None

(b) Bridge Type
- Cast-in-place
- Precast
- Structural steel
- None

(c) Intersection Type
- At grade
- Elevated
- None

(d) Miscellaneous Type

4. What Time of Year Will the Project Begin?

5. What is the Phasing Factor?

6. Input the Following Location Factors

7. What is the Contractor Factor?

Transportation Research Board (TRB) Paper Submittal

Due to the innovative ideas and concepts of the fourth project classification scheme, a research paper was prepared for presentation at the annual TRB conference. This paper presents current contract time determination (CTD) methods, problems associated with the current CTD methods, the idea of template orientation for project selection/classification, and both a designed-based (top-down) and a feature-based (bottom-up) approach to selecting templates. The paper was presented at the TRB's 74th Annual Meeting, January 22-28, 1995, in Washington, D.C. A copy of this paper is included in Appendix A.

Contract Time Template Development Workshop

Having determined that a template-based contract time determination system would be developed, several questions arose. How many templates should be provided in the computerized system? What major categories of construction should the templates address? What work items should be included in the templates? How can the temporal relationships among work items be specified in the templates? How can we be sure that the templates accurately model typical construction processes?

We determined that the best way to answer these and similar questions was to ask the experts, the LaDOTD construction engineers. Therefore, with the enthusiastic support of the LaDOTD's Construction Section and Contracts Section, a Contract Time Template Development workshop was scheduled for August 23 and 24, 1994, on the Louisiana Tech campus in Ruston, Louisiana.

After initial presentations regarding the purpose of the workshop, three major sessions were held. During the first session, the most commonly occurring instances of the construction categories previously specified were identified. The Nominal Group Technique was used as the tool to guide the development of this list. Following this, a list of the most common construction project features was developed for each construction category using a similar technique. During the last session, small teams of construction engineers created the project templates by identifying and sequencing construction work items.

As a result of the workshop, twenty-three construction templates were developed, and are ready for adaptation into a computerized system. The summary of construction features for each project template and the work item/sequencing information are included in the CTDS User Guide which is in Volume III of this report.

Project Selection for Comprehensive Production Rate Analysis

Because a key to a template-based CTDS is using accurate work item production rate values, a major effort was directed toward establishing these rates. This was done by reviewing the LaDOTD's daily reports for approximately 100 completed construction projects. To generate production rates as they apply to the various types of construction categories, projects were selected so that they match as

nearly as possible the construction categories identified in the Template Development Workshop.

As a first step in selecting the projects for each template, an extract of the LaDOTD TOPS database was obtained. The extract file contained all the fields for all construction projects completed in the last three fiscal years. There were over nine hundred records in the extract file. The file was sorted by various categories in an effort to identify projects for which daily journals could be requested. A list of 100 projects was selected based on the characteristics noted in the TOPS database. However, upon review of this list by the LaDOTD Construction Division, many of the selected projects did not sufficiently match the template feature requirements. Consequently, each LaDOTD district office was sent an exhaustive list of recently completed projects in their respective district. The project engineers from each district matched the projects to a template.

Since the scope of the research only allowed for 100 projects to be analyzed, not all of the categorized projects could be used. The final list of projects for use in the study was completed by random selection from the pool of projects categorized by the LaDOTD officials. Finally, the daily reports for the randomly selected projects were gathered and sent to Louisiana Tech University.

Contract Time Determination (CTD) Software Development

Initial Custom Software Development

The primary objective in developing the custom software was to develop a model that simulates actual activities. The methods currently practiced at LaDOTD served as a guideline for the orderly construction of this model.

To achieve a physical realization of the activity being automated, instead of configuring the system as one whole component, it was decomposed into smaller parts. This process was followed by returning to the decomposition stage recursively to define further smaller components (object). This was done with a focus on the functions and data passed between these functions, and translating them from the user terms into object-oriented concepts. Later, these objects were identified in the user's world as they appeared and were arranged in hierarchy to complete the flow of information (data and functions).

Considering the fact that Excel 5.0 is object-oriented and its ability to integrate with Microsoft Project, this model was developed to characterize the user interface, data extraction, and graph drawing features.

Application Development Using Spreadsheets

Excel makes working between workbooks easy and also has the capability to contain different kinds of documents, dialog sheets, macro module sheets, worksheets, charts, etc., in one workbook. It is for this reason that all the details of this application were created and stored in one workbook. Interaction with all the components of the workbook could be done through control buttons on the tool bar and menus on the menu bar. If the entire application were to be assumed to be one huge container, then the workbook, menus, and controls would be objects. The workbook, in turn, would hold components such as worksheets, dialog sheets, macro module sheets, etc. The user interface was described as a series of dialog boxes, through which inputs were read into the application. This allowed data, endemic to a particular construction category to be extracted from the database and displayed on the screen. The database contained details on each construction activity, production rates, and activity overlap. On the click of a button, customized on the tool bar, a chart would be generated showing contract time. Other details like database protection were also incorporated to prevent unauthorized use and damage to the application.

The Excel prototype of the contract time determination application was presented to personnel from the Contracts and Specifications Section, Construction Division, Louisiana Transportation Research Center (LTRC), and the LaDOTD Computer Center in November, 1994. Computer Center staff expressed concern regarding future support of the system if it were not developed using one of the officially supported application environments, none of which supported a graphical user interface which was a keystone of the proposed system. After considerable discussion, it was agreed that the application would be developed using Lotus 1-2-3 Release 5 for Windows, recognizing that some functionality could possibly be sacrificed as compared to the same application developed in the Excel or Object-Oriented C++ environment, as originally proposed.

Final Application Development and Delivery

The first prototype of the contract time determination application using Lotus 1-2-3 R5 for Windows was installed December, 1994. Subsequently, four updates were

delivered and installed. Fifteen LaDOTD personnel participated in operator training sessions on July 14 and July 21, 1995. System support training for Contracts Section and Computer Center personnel was conducted on August 16, 1995.

The Conceptual Design Report and System Design Report for the software are included in Volume II. The (CTDS) User Guide is included in Volume III. The CTDS System Documentation, including full source code listing, is included in Volume IV.

Methodology Used for the Production Rate Analysis

The templates define certain types of projects by identifying features of work type, location, primary materials, length, etc. Consequently, each template contains an independent set of production rates. Once all the projects were analyzed from within a template, the production rates for that template could be calculated.

The first step in this methodology was to process the information from the daily reports into a computer spreadsheet. A condensed format for this process was devised. This format included information for the calendar day, whether the contractor worked, whether a working day was charged, the work items performed, and the material quantities for the work items. The work items were listed in the spreadsheet for each day and the process continued until the project was complete.

To compute the production rates for any of the templates, the needed variables were the total material quantity for each work item and the number of days that were spent working on each work item. Initially, both variables proved to be difficult to identify in the daily reports. It was not uncommon for the inspector to describe the activities for the day using vague language rather than the LaDOTD work item code. Therefore, the research investigator would have to fully read each report and apply reasoning to understand which work item(s) the contractor was working on. In addition, many instances occurred where the inspector would only list the type of work performed and not list any material quantities initiated and completed that day. These problems were partially solved by using the final estimate to guide the work item identification process. The final estimate lists all of the work items completed on a project along with the material quantities. The identification of work items in the daily diaries became much simpler by using the final estimate. However, identifying the material quantities was still a problem. Since the final estimate includes the final values for which the contractor was paid, the research team decided to place more

confidence on the material quantities from the final estimate rather than the quantities identified from the daily reports.

After each project in a template was analyzed, the project files were combined and sorted by work item. Next, the sum of the daily quantities for each work item was computed. This value was compared to the sum of the work item quantities from the final estimates. Once the two values were compared, one of two scenarios could result: (1) if all of the daily values for the work item were identified, a modifier was developed to increase or decrease each daily value so that the sum would equal the final estimate sum, (2) if there were days where the inspector noted that work was performed on a certain work item, but did not note any material quantity, a material quantity value of "zero" was used for that day. Then, the sum of the daily values for each work item was compared to the sum of the final estimate work item quantities. If the daily sum was less than the final estimate sum, the difference was distributed equally to each of the "zero" days. If the daily sum was greater than the final estimate sum, a modifier was developed and applied to each of the daily values so that the sum of the daily values equaled the sum of the final estimate work item quantities. Once the daily values were modified, the production rates were computed.

The production rates were generated by computing the mean value of the daily material quantities for each work item within each template. In addition, a 95% confidence interval was computed for each work item production rate. The production rates for each template are shown in Appendix D and the statistical analyses for the production rates are shown in Appendix E.

METHOD OF PROCEDURE (SUB-PROJECT B)

The research team began this project by gathering, reading, and studying state-of-the-art literature on innovative contracting concepts. The sources reviewed came predominately from the following organizations:

- National Cooperative Highway Research Program (NCHRP), Synthesis of Highway Practice;
- American Society of Civil Engineering (ASCE) *Journal of Construction Engineering and Management*;
- American Institute of Architects (AIA), contract documents;
- Construction Industry Institute's (CII), contract documents; and
- Wiley Law Publications, Construction Law Library.

Information contained within these documents included articles on such things as Quality Assurance, End Result Specifications, Value Engineering, Warranties, Partnering, Prequalification, and Cost Plus Time. These publications presented a broad spectrum of information regarding these topics and more precise discussions of state-of-practice definitions, strengths, weaknesses, and implementation procedures.

As a supplement to the literature review, Transportation Research Board (TRB) members were contacted due to their expertise in the field. These individuals provided valuable input on many of the concepts. In addition, the research team contacted specific states who have experimented with some of the innovative concepts and asked for crucial input on the processes and procedures used to implement the techniques as well as the overall satisfaction of use. From this information, we compiled a survey that was sent to all State DOT's and asked for a response in such areas as use, satisfaction, and areas affected by the use.

To become knowledgeable in the current practices of the LaDOTD, several meetings were held with the LaDOTD officials. The meetings were conducted, on a one-to-one basis, with officials in the design and construction sections of the

LaDOTD, including, eight engineers and one attorney. The research team prompted questions on several innovative concepts, and the LaDOTD officials responded. From the interviews, we were able to determine which innovative concepts were used by LaDOTD, which concepts LaDOTD would like to use, and why LaDOTD has not used or does not want to use specific innovative concepts.

The research team also conducted four postal surveys using Innovative Concepts Questionnaires. The questionnaires were similar in content, but were individually designed to address four different groups of professionals:

- Questionnaire Number 1 went to all 50 State DOT's,
- Questionnaire Number 2 went to LaDOTD's construction engineers,
- Questionnaire Number 3 went to construction contractors in Louisiana, and
- Questionnaire Number 4 went to engineering consultants in Louisiana.

Following the initial mailing of the questionnaires, the researchers mailed a follow-up reminder (post card) to each non-responsive individual. As a final reminder, the researchers contacted each non-responsive individual by telephone.

The team took the responses from the questionnaires, and tabulated and conducted statistical tests on them. Because the distribution of the responses was unknown and not needed in this study, non-parametric (or distribution-free) statistical tests were conducted, specifically, the Kruskal-Wallis Rank Order test. Finally, all information gathered from all officials, by interview and questionnaire, were analyzed and compiled into this report.

DISCUSSION OF RESULTS (SUB-PROJECT A)

Current Contract Time Determination (CTD) Methods

Previous studies regarding highway projects revealed several methods by which contract time can be determined (1, 2). These methods range from subjective estimates to systematic procedures and can be classified as follows: (1) subjective *ad hoc* techniques, (2) estimated cost techniques, (3) quantity/production rate-based (QPR) techniques, and (4) scheduling techniques.

Subjective Ad Hoc Techniques

This method involves a manual review of the project characteristics and work activities. The contract time is determined subjectively by experienced personnel.

Estimated Cost Technique

The estimated cost method of determining contract time assumes that contract time is mathematically related to the agency's prebid cost estimate.

Quantity/Production Rate (QPR) Technique

The QPR approach estimates the contract time by computing the time required to complete selected work items in the project. These computations are performed by simply dividing the estimated plan quantities by respective assumed production rates. For example, if a project requires 7,400 square yards of concrete pavement and the assumed production rate is 1,500 square yards per day, 5 days of contract time would be allotted for completion of the task. A summation of the estimated times for all tasks, plus any allowances for special provisions, yields the estimated time for the entire project.

Scheduling Techniques

Scheduling techniques, while successfully used by contractors, have not found widespread use by DOT agencies. The most common methods are the Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), Bar Charts, and Line-of-Balance methods (LOB).

Each of these techniques includes graphical illustrations of discrete construction activities. The graphical representation used by the bar chart method provides the most universally accepted format for displaying time relationships among work items. The chart format typically consists of horizontal bars representing work items

having lengths consistent with the time-scale located on the abscissa. It clearly shows the starting point of each work item and its duration. Concurrence and overlap of work items are also obvious by the presence of multiple horizontal bars at any location on the time axis. This method of display is similar to the technique used in the LOB method.

The CPM and PERT techniques are considered network methods owing to the style in which they are graphically displayed. Differing from the bar chart method, CPM and PERT display interdependencies of the work items. Traditionally, these diagrams are not shown on a time-scale axis.

Problems Associated With The Current CTD Methods

Subjective Ad Hoc Techniques

As mentioned above, this is the most subjective method. Introducing subjectivity into contract time estimates limits reproducibility. Contract time determined by this technique also have a high range of variability that depends on the individual performing the estimate.

Estimated Cost Technique

This method is the quickest, but is the least desirable (1). It requires constant monitoring to ensure applicable rates of economy, labor, and construction techniques.

Quantity/Production Rate (QPR) Technique

The validity of contract time estimates prepared using QPR rests on two key assumptions:

- The work items included in the calculation of contract time are assumed to include all the *controlling* items, i.e., other work activities may be ongoing simultaneously, but the items listed are the ones that must be performed sequentially and thus dictate the required time for the project (they form the critical path).

- The production rates for the items are compatible with the project characteristics.

In addition, an ongoing review of the CTD processes of the LaDOTD has identified the following circumstances under which QPR yields inaccurate contract times:

- A single list of controlling items is not appropriate for all projects. For example, a road overlay project using asphaltic hot mix will typically involve some concrete work for curbs and driveways. The estimated plan quantities for both materials will be listed, yet it is likely that only the asphalt work will be the controlling item since the concrete work can be done concurrently.

- Projects characterized by long linear length or general complexity offer opportunities for several work items to be undertaken concurrently. For example, a long overlay project may permit concurrent work on both curbs and road surface.

- Production rates for a single item may vary by application. Asphalt applied in the traffic lanes would be expected to have a higher production rate than asphalt applied on the shoulders. Unfortunately, only the total quantity of asphalt is likely to be shown in the estimated plan quantities.

- Phasing of a project affects the contract time. Additional time must be allowed for traffic management, equipment relocation, and other transitional factors because the project is divided into smaller parts.

Scheduling Techniques

All scheduling techniques have particular disadvantages in the CTD process. For example, they all require extensive knowledge of the construction process so that the predecessors and successors of each activity can be properly selected. They also require accurate activity durations computed from production rates that are consistent with project characteristics. Another problem with scheduling techniques is that they require more data preparation and computation.

Rationale For a Template Orientation

Each CTD tool presented in the previous section has strengths and weaknesses. A particularly appealing approach combines the ease and simplicity of QPR for data entry, the computational rigor of scheduling techniques for activity sequencing, and the clarity of bar charts for presentation. A CTD system of this type was recently

implemented by Texas DOT (3). This hybrid method makes use of a concept we call the CTD Template. In this context the term *template* means a logical framework that incorporates a list of controlling work items, production rates for the items, and temporal relationships among the work items. Thus, the template addresses the scope of the proposed project through its inclusion of appropriate work items, the magnitude of the project through calculation of work item durations based on supplied quantities and production rates, and concurrence and overlap among the work items. The work items and their interrelationships are placed in a template based on the experience of construction engineers and/or historical contractor performance data. A template is designed to represent accurately the typical sequence of controlling work items for a construction project of a particular class. If the template provides no overlap or concurrence relationships among the work items, the procedure becomes identical to QPR.

A template contains each applicable work item in unit quantity. To compute the contract time, the appropriate template is selected and estimated plan quantities for all work items are entered into the template. The concurrence relationships among work items are preserved as the template bar chart is scaled along the time axis by the length of the controlling item durations as calculated from the template production rates and item quantities. The contract time is the value on the time axis corresponding to the right most extent of the last bar. Manual overrides of production rates and concurrence/overlap relationships should be provided. Additional time allowances for special provisions must also be included. Further modification of the calculated time, owing to unusual timing, location, traffic, or other work conditions, can be achieved through appropriate scaling factors.

A repertoire of project templates must be available for selection. The repertoire must include a template for every distinctively different type of construction project likely to be encountered. For example, the template for a pavement overlay project would be significantly different from a template for a bridge replacement project. The use of templates also allows more subtle distinction among project characteristics. For example, a short length overlay project would afford little opportunity for concurrent operations. Therefore, a template for this type of project would be different from a template for an overlay project of a similar road but having a much longer length.

Proper selection of the applicable template removes many judgement decisions required in the simple quantity/production rate system and should yield more consistent and defensible contract time determinations.

Production Rate Analysis

Once the production rates from the trial analysis were established, there was a need to validate the rates by conferring with LaDOTD officials. The rates were examined by the LaDOTD officials after a brief description of how they were derived. After the discussion, an agreement was made between the research team and the LaDOTD officials that deriving production rates by this method generates reasonable values. With respect to the agreement, the methodology was implemented on the selected projects.

Problems and Assumptions of the Production Rate Methodology

When computing production rates using this methodology, several problems and assumptions occurred. The problems and assumptions range from inspector reporting quality to inconsistencies in the investigators analysis. These problems and assumptions are listed and discussed below:

- Since approximately one hundred projects were studied, resulting in nearly 50,000 daily reports processed, inconsistencies with inspector reporting format were discovered. The ideal situation was for the inspector to note (1) the calendar day, (2) whether the contractor was charged a working day, (3) the LaDOTD work item codes that the contractor performed work on that day, (4) the material quantities for each work item, and (5) the duration spent on each work item. However, the ideal situation never occurred because the inspectors never listed the time spent on each work item.

- Once the work items for each day were identified, the problem of assigning a time-value associated with the work item quantity arose. Often, the inspector would note the total amount of time the contractor was present on the job. But, in these cases there were no indications about how the contractor divided the time among the work items. As a result, each work item listed on each report was assumed to have a time value of one day. This assumption is the basis for computing the mean value.

- Due to the overwhelming number of reports that had to be analyzed, as many as three research investigators conducted the analysis. Although attempts were made to minimize the inconsistencies in daily report interpretations, it is reasonable to assume minimal differences exist among the way the investigators awarded work to the work item codes. For example, a daily report might have a comment that describes that the contractor was "tying steel." This comment could perhaps be awarded to many work items within the project. The approach taken was to assume they are "tying steel" on the same work item as the day before or the day after. Assumptions and interpretations such as this are built into the production rates. However, it is felt that these discrepancies have a minor impact on the end result of the calculated production rates.

- The LaDOTD officials identified 23 templates that describe different types of highway construction projects. To generate the production rates to be used in the templates, a statistically significant number of projects needed to be selected for each template. However, the scope of this research only allowed for the analysis to include three to five projects from each template. Using the data from the projects within a template resulted in a range of one to approximately one thousand data points for each work item. (data points represent the daily material quantities initiated and completed in one day)

- Many of the work items identified were paid on a "lump sum" basis. These "lump sum" items are difficult to analyze for two reasons: (1) the inspectors rarely identified the daily quantities associated with the "lump sum" work items, and (2) the final estimate also recognized the work items as "lump sum" (hence a quantity of one, regardless of project size). As a result, the investigators could not identify nor compute the total material quantities. Therefore, the production rates for the "lump sum" work items were not computed. Additionally, many of the templates require input, quantities and production rates, for the "lump sum" items. Consequently, to utilize these templates requires additional research to obtain production rates for these work items. The number of observations for each of these work items are shown for each template on the Statistical Analysis forms found in Appendix E.

- The computation of the production rates assumes that the data are normally distributed. This assumption is used in computing the mean and the 95% confidence interval for each work item.

- The scope of this research was limited to the development of the contract time estimating system. Because of this limitation, validation of the generated production rates has also been limited. These production rates have been compared to the production rates currently used by the LaDOTD Contracts and Specifications Division and to the rates used by other DOT agencies.

Work Item Analysis

The results of the work item analysis proved to be insignificant. After applying several statistical analysis procedures, very few major work categories (the LaDOTD project classification scheme was used for this analysis) showed any relationships to work items. As would be expected, some work items did appear in the majority of the projects. However, finding relationships between the major work items and at what instance they appear in a project could not reliably be predicted by the use of this method. The Contract Time Template Development Workshop proved to be very beneficial for the selection of work items and their relationship with other work items within the construction process.

Performance of the CTD Software

Factors Affecting Accuracy

A comprehensive validation of the LaDOTD CTDS is beyond the scope of this project. The following factors are expected to significantly affect the validity of the contract times as calculated by CTDS:

- Proper template selection by the contracts technician. Since the templates defined in the software include both the list of typical work items for the selected construction class and the work activity phasing among the work items, it is essential that the proper template be chosen. The CTDS User Guide suggests that the technician creating the initial contract time calculation consult with the contracts engineer, prior to using CTDS, to agree on which template best fits the proposed project.

- Proper production rates for work items. The production rate analysis task of the project was conducted to extensively review recently completed construction projects to determine justifiable production rate values. This analysis was conducted on a per template basis, i.e., production rates for work items were calculated based on observed values for construction projects of the same general nature. This is expected to be a major improvement over the previous manual system which employed uniform production rates over all types of projects.

- Accurate data entry by system operators. Several features were designed into CTDS to increase the reliability of data entry. The system enforces required data entry in all work item quantity fields, thus requiring the technician to carefully consider the quantity of each work item before proceeding. Overrides of production rates are color coded for easy identification. Instant display of work item durations, total contract time, and the construction sequence bar chart assist operators in identifying out-of-range data items. Finally, the multiuser interface cleanly provides for easy checking of previous operator data entry.

- The consistency of work day charges by inspectors. Any attempt to reconcile estimated contract times with work progress on a specific job requires that work days be charged in a consistent manner.

Sample Results

Data from four completed construction projects were supplied to the CTDS program to compare results with the manual procedures and actual duration of the construction project. In Table 1, four durations are given for each project. The first column contains the LaDOTD project identification number. The second column contains the contract time as computed by the manual procedure previously used by the Contracts Section. The third column contains the contract time as calculated by CTDS, but using the same production rates as the manual method. Differences in durations as shown in the second and third columns are attributable to work item overlap and activity concurrence as defined by LaDOTD construction engineers in the template. The fourth column contains durations calculated by CTDS using production rates derived from a review of completed projects. The final column lists the actual number of work days charged to the project by the field engineer.

Table 1. Comparison of Contract Time Calculation Procedures

Project Identification	Contract Time Calculation Method			Actual Project Duration
	Manual Procedure	CTDS with Old Production Rates	CTDS with New Production Rates	
829-04-0015	65	55	36	59
845-06-0038	50	44	44	66
804-10-0013	50	31	36	49
225-02-0014	75	56	37	80

DISCUSSION OF RESULTS (SUB-PROJECT B)

The literature review and the postal questionnaire provided several state-of-practice insights into the strengths and weaknesses of each innovative concept. A summary of the responses to the postal questionnaire can be found in Appendices F and G.

Postal Questionnaire Number 1 Results

A postal survey was conducted by the research team at Louisiana Tech University to determine the current state of innovative contracting practices in State DOT's. The sub-objectives of the survey were to determine the following:

1. What types of innovative contracting concepts have been used?

2. How satisfactory or successful these concepts have been? and

3. When these concepts have been applied?

Questionnaires were sent to all State DOT's and the 40 responses received were statistically analyzed. Appendix F summarizes the results of the survey.

The responses showed that the most widely used concept was partnering with 100% of the states using or considering it. Value Engineering was the next most widely used concept with 39 (98%) states either using or considering it. Almost 90% of the states were using the concept of Quality Control/Quality Assurance (QC/QA). The least used concepts were Cash Allowances (3%), Build Own Operate Transfer (BOOT) (10%), Construction Management (25%), and Design/Build (35%).

A statistical analysis was conducted using rank-order statistics. The results were deemed significant when the Kruskal-Wallis test statistic value was statistically significant at or above the 95% level. The statistical analysis revealed several significant pieces of information:

- Perhaps most significant is that users of innovative concepts are highly satisfied with the concepts results; owners were very satisfied with Performance-Related Specifications, End Result Specifications, Quality

Incentives/Disincentives, and Prequalification. Satisfaction was also high with QC/QA and Dispute Resolution.

- All concepts were found to have a positive effect on Design Quality;

- All concepts, except A+B and Lane Rental, have a positive effect on Owner-Contractor Cooperation, and Engineer-Contractor Cooperation; (A+B and Lane Rental negatively effect Owner-Contractor Cooperation and Engineer-Contractor Cooperation);

- The analysis also showed that these concepts significantly effect Construction Costs and Amount of Litigation/Claims, some concepts increase costs and claims (e.g., A+B and Lane Rental), others decrease costs and claims (e.g., Partnering and Dispute Resolution); and

- The concepts have little effect on Construction Quality, Owner-Engineer Cooperation, Number of Change Orders, and Life-Cycle Costs.

Some general conclusions can be drawn based on the consistent responses given by the states:

- Partnering is working.

- End Result Specifications, Performance-Related Specifications, and QC/QA is working.

- Value Engineering is widely used and satisfying.

- Cost Plus Time and Lane Rental significantly decrease contract time, but at the expense of total costs, including construction costs, change order costs, and litigation costs.

Postal Questionnaire Numbers 2, 3, and 4 Results

The research team at Louisiana Tech University also conducted surveys to determine the current attitudes and perceptions toward innovation contracts in the Louisiana highway construction industry. The objectives of the survey were to determine the following:

1. The types of problems that are present, if any,

2. The causes of these problems, and

3. Possible solutions to these problems.

Questionnaires were sent to three elements of Louisiana's highway construction industry: LaDOTD construction engineers, engineering consultants, and construction contractors. Forty-six (of 58, or 79%) LaDOTD engineers completed the questionnaire and mailed it back. Forty-one (of 88, or 47%) contractors mailed back their completed questionnaires. Nineteen (of 58, or 33%) engineering consultants mailed back their completed questionnaires. Appendix G summarizes the responses to the survey.

- The survey found that all groups, contractors, designers, and LaDOTD construction engineers, were familiar with the concepts of Subcontractor/Supplier Approval and QC/QA, but were unaware of Lane Rental and Cash Allowance. Familiarity was also high for Partnering and Guarantee/Warranty, but low for BOOT (privatization), Value Construction, and Dispute Resolution Board.

- All groups concurred that more improvement is needed in the area of dispute resolution, communication between contractor and LaDOTD, and clearness and correctness of plans and specifications. However, respondents indicated that contract time estimated by LaDOTD and the charged working days needs little improvement. Although, contractors believe that contract time estimated by LaDOTD could be lengthened.

- According to the respondents, there were more disagreements than disputes. The primary cause of disagreements and disputes is design errors and omissions; site access caused the least disagreements and disputes. Most respondents agreed that a dispute review board would help in solving disputes. The dispute review board would help reduce litigation and disputes in a timely fashion. The respondents generally agreed that the decision of the dispute review board should be contractually binding.

- Several respondents (41%) indicated that there is an adversarial relationship between most contractors and the LaDOTD. These same respondents also indicated that negative effects on construction quality result from that adversarial relationship. These respondent believe that partnering would help this relationship, and the benefits for using partnering would outweigh the costs.

- All groups agreed that contractors should warrant work, workmanship, materials, and final product performance (independent of design). The recommended time period for a warranty ranged from one to two years. Most respondents believe that Guarantees/Warranties can be enforced.

- On the question about Incentives/Disincentives, there was a mixed response. While the contractors agreed on the idea of submitting a completion time with their bid, and with the idea that LaDOTD should provide incentives, the LaDOTD was unsure about the concept. The recommended range of the time incentive was found to be between $1000 to $2000 per day, with the following criteria recommended for inclusion in calculating the time incentives (in order of preference):
    - Average daily traffic,
    - Increased likelihood of accidents,
    - Property owner inconvenience,
    - Increase time for user delays, and
    - Impact on detoured route.

- There was a mixed response on whether or not to liquidate the contractors damages.

- The respondents agreed that contractors should not be charged for lane closures, but that it may help projects to be completed more quickly.

- For Design/Build contracts, respondents believe there will be
    - an increase in the use of innovative construction practices,
    - an improvement in communication between the designer and contractor,
    - a decrease in the number of plan changes, and
    - a decrease in the number of disputes.

- The respondents equivocally agreed that the district construction engineer and project engineers should have more authority. All believe that this additional authority would improve the communication between the contractor and LaDOTD, while reducing the number of disputes and plan changes. There was a general consensus that LaDOTD inspectors should not have more authority.

Privatization

Privatization is an innovative concept because it passes responsibility for ownership of a facility traditionally held by the granting authority (the public agency, e.g., the State of Louisiana), to the contractor for a long period of time. This type of construction involves the following three parties:

- A granting authority, such as the LaDOTD, responsible for long-term control of the project;

- A project sponsor, such as a developer, responsible for constructing and/or operating the facility, this is the party that stands to gain a profit; and

- A financier, such as a bank, responsible for financing the project (4).

The typical privatization process can be briefly summarized as follows:

1. After competitive bidding, the project sponsor (contractor) takes on the physical and financial risk of construction and ownership of the project.

2. Once the construction is completed, the contractor is responsible for the maintenance and operation of the finished product for a predetermined time period. (Often, the maintenance and operation of the facility is immediately turned over to the granting authority. Profit is earned by the developers' ownership of surrounding property that has escalated in value.)

3. The ownership of the product is then transferred from the project sponsor to the granting authority in exchange for some predeterminable dollar bid amount (4).

Privatization has been widely used in European countries, and in many U.S. public sector projects, but has found only limited application in the U.S. highway sector since the 1980's (5). Legislation regarding use of this concept has been passed in Texas, California, Florida, and Colorado, and is being considered in Virginia and Illinois (6). One reason for its acceptance is that it offers an alternative to traditional contracting where public financing is limited (4,6,7). According to Federal Highway Administrator Ray A. Barnhart, public tax monies will not satisfy all of the highway needs (6). "To bridge the gaps, the private sector is forging a key leadership role and uncovering billions of dollars of funding for sorely needed projects" (6).

A good example of a privatized project is the "1986 South Parkway Agreement" in North Carolina. Approved by the state legislature, the agreement called for four landowners to donate 3.4 miles of right-of-way valued at $8-million to the N.C. Department of Transportation. The landowners also paid half of the $6.2-million construction costs for a four-lane highway. In exchange, the landowners would be able to develop their parcels of land with almost complete assurance of profit. The landowners hired a firm to design the entire project, let the grading and drainage contract, and perform inspection. After completing the grading and drainage aspect of the project, the landowners turned the project over to the DOT (8).

This example illustrates some of the benefits of privatization. The concept allows projects to be completed with much lower initial costs. In the above example, a much needed roadway was constructed without the DOT paying for the land and half of the construction costs (8). Another benefit of the use of this concept is that projects can be completed more quickly since the granting authority does not have to initially furnish the money for the acquisition of the land (8). Additionally, the project sponsor is usually responsible for maintenance of the completed product, therefore higher quality is typically built into the product (7).

However the American Federation of State, County and Municipal Employees (AFSCME), through an in-depth study, showed that this type of contracting may have serious downfalls. A significant weakness of privatization is that the granting authority may pay more for the final product rather than saving money. The hidden costs related to contract preparation, administration, and inspection of the contractor's performance are often over looked early in the planning stages (9). If this happens, the cost effectiveness of the concept is diminished. Additionally, the quality of the product may be diminished if the granting authority is unable to

adequately control the product and material specifications. If the contract is vague, the granting authorities may have problems getting what is needed for the agreed-upon price (9). A third problem is that competitive low bidding of the contract is not consistent with the success of a project. The low bid process does not allow the owner to focus on more important factors, such as design competence, construction competence, reputation, ability to operate and maintain the product, and financial stability (10).

Cash Allowances

A cash allowance is a term that refers to a process that allows the owner to set a fixed cost for equipment or materials within the bid proposal. Contractors place their bids on the basis of these cash allowances. Separate bids are received from equipment or material suppliers. When the prime contract is awarded, the owner selects, using the lowest qualified bid, both the supplier and the contractor. Adjustments to the selected contractor's contract sum are then made based on the selected supplier's bid. Items that are covered by the cash allowance are furnished by the selected supplier.

By using cash allowances, the owner is theoretically able to obtain the lowest possible cost for labor, supplies and materials, and equipment. The major advantage of using job-order-contracts as a cash allowance is, as a Total Quality Management (TQM) concept, incentives are implied for both the owner and supplier. While the owner is assured a higher quality product, the supplier, by producing a better product, is assured that his job will continue. The supplier does not have to compete for another contract (11).

When using cash allowances, misunderstandings may arise concerning what specifically is encompassed within the cash allowance. Areas of discrepancies often include taxes, unloading and handling costs, installation costs, overhead, and profit (4). Additionally, cash allowances may theoretically result in the lowest possible cost but in reality it may not. Government agencies are typically charged more for materials than contractors because construction contracts are more competitive and suppliers apply the concept of supply and demand (12).

Job-Order Contracting

Another form of a cash allowance is job-order contracting. The supplier, chosen through competitive bidding, signs a long term contract with the granting authority

(12). This contract allows the supplier to provide materials to general construction contractors for a predetermined time period (independent of construction projects) as long as satisfactory material is provided (12).

Military job-order contracts have been used successfully on various types of projects. Holmes and Narver Construction Services, Inc., has decided to use their experience with military job-order contracts and apply it to other public and private clients. As a trial, the Federal Government has used job-order-contracts for construction, repair, renovation, and maintenance projects. Use of this contract showed that more than 60% of a facility's construction needs could be completed (12).

Construction Management

Construction Management developed because of the inability of designers and contractors to use effective management skills (4). Construction management was intended to provide a better interface between the contractor and designer. A third party who is experienced in both construction and design is added to the team of owner, designer, and contractor. Outside construction managers contract with the owner to act as the owner's agent or representative throughout the project (13).

In concept, two of the primary benefits of construction management are that the design is more constructable and the owner's needs are better met. The construction manager reviews the design before advertisement for bid in order to detect any possible problems that may occur during construction. By doing so, changes during construction due to errors in the design or plan changes are lessened. This in turn may decrease the number of disputes. In this way, the owner's needs are met and costs due to litigation and delays are held to a minimum. Use of construction management may include major reductions in construction time and cost (14). The most common approach to reducing time and cost with the use of this method is through "phasing" or "fast tracking." This includes constructing in segments while other areas of the project are still being designed (14).

The success of construction management is dependent upon the management skills and knowledge of the construction manager. This manager acts as an adviser to the owner. Because the owner retains the authority to approve contractor payments, the construction manager's lack of authority hinders his ability to control and manage the job site (14). With this added party, a source of conflict may result if the

construction manager's ideas and opinions are not in agreement with either the owner or the contractor. In addition, construction managers, without incentives tend to perform at minimum standards to meet contract requirements and maximize their profits. This fact provides an added opportunity for adversarial relationships to foster (14).

Contractor Prequalification

Introduction

In general, prequalification is a process for screening prospective contractors according to a predetermined set of criteria designed to measure a contractor's ability to meet the project's objectives. Figure 1 illustrates the tri-cyclic nature of the prequalification process. In the construction industry, the screening is done by the project owner, using prespecified criteria designed to measure a contractor's competency to successfully construct a specific type of project. During screening, the owner places the contractors into one of three categories: prequalified, non-prequalified, or debarred. This categorization lasts until the next analysis. In the interim, the contractor accrues experience, equipment, and finances to be used in the next prequalification analysis.

The key to measuring contractors' competence is for the owner to ask the right questions regarding the contractors' performance (15). To effectively perform prequalification, the owner should evaluate several characteristics, including: (1) financial status, (2) resources, (3) technical and managerial expertise, (4) references, reputation, and past performance, (5) status of the current work program, and (6) project-specific requirements.

Traditional Prequalification Systems

Traditionally DOT's either did not qualify contractors at all, or only post-qualified the lowest bidder. The responsible bidder, in most cases, is defined based on passing a brief unstructured analysis of the contractor's qualifications and on meeting certain legal criteria, including being bonded by a licensed surety and having a valid contractor's license from the state.

In post-qualification, owners rely on bonding to protect their interest. The bonding agencies conduct the qualification analysis, and carry the risk of the contractor's default. In spite of this analysis, some contractors with highly questionable qualifications are bonded, raising the potential for project default. These contractors

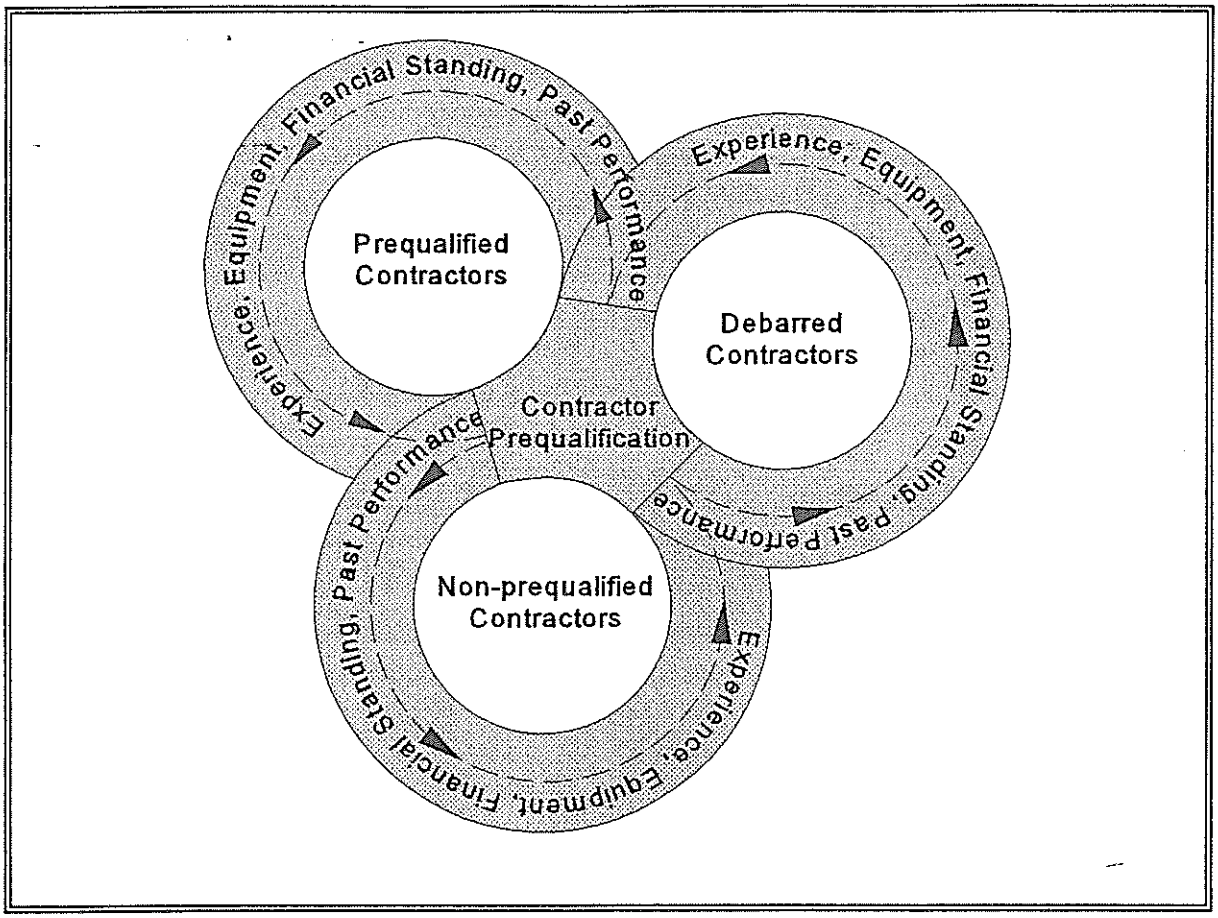

Figure 1 The Tricycle of Prequalification.

are bonded by paying higher premium, by using inefficient bonding agencies, by receiving consideration because of the bonding agency's economic situation, or by providing enough indemnity resources. Telephone conversations with surety industry representatives confirmed the following:

- Surety underwriters do not have standard procedures for analyzing contractors' qualifications, but depend on personal experience and judgment.

- A contractor can be qualified by one surety underwriter and disqualified by another underwriter from the same or another firm.

- The premiums paid by contractors varies from contractor-to-contractor (as expected), from surety-to-surety, and from time-to-time.

Some owners conduct their own separate post-qualification analysis in an attempt to screen those questionable, but bonded, contractors. However, rejection of the lowest bidder is very difficult and a potential source of dispute and loss to both the owner and the contractor.

Surety firms may have some advantage over the owner in conducting prequalification, including higher access to the contractor's internal records and longer term relationships with the contractor. On the other hand, the owner has some advantage over the surety firm in knowledge about the particular type of construction and in the minimum resources (managerial and technical experience of the principal individuals, and equipment) required for that particular project.

Because of this limitations to the traditional system, many owners have implemented some type of prequalification procedure, typically emphasizing financial capability of the contractor using the contractors' financial statements. These procedures look at a contractor's financial ratios, taken from the contractor's financial statements, as compared with average financial ratios, taken from industry averages. However, because financial analysis can only measure a contractor's financial stability and capability, other characteristics, equally important to financial ability, are beginning to be incorporated into prequalification schemes.

The Pros and Cons of Prequalification

Prequalification is beneficial to all parties in the construction process: the owner, engineer, contractor, and the construction industry. It provides the owner the following benefits:

- reduces the risk of default on the project by ensuring that only competent contractors are invited to bid for the project;
- maintains fair competition among contractors to ensure the best price;
- reduces the cost of printing a large number of contract documents and analyzing a large number of bids; and
- reduces inflationary cost from unproductive expenses resulting from studying, analyzing, estimating, and submitting a large number of bids

when only one of them will be successful. This cost, factored into the contractor's overhead, ultimately results in higher contract prices.

Prequalification also benefits the contractor as follows:

- reduces the expenses associated with preparing bids for projects the contractor is not qualified to undertake,
- guarantees serious competition among qualified contractors,
- helps unqualified contractors identify and strengthen weaknesses so that they can qualify for future work, and
- improves the competitiveness among national contractors in the international construction market.

In addition, the construction industry in the US will benefit as follows:

- produces higher quality products within budget and schedule by ensuring that the selected contractor is able to meet the project's needs and objectives, and
- lowers the risk of contractor default that surety companies are carrying, ultimately resulting in reduced insurance and bonding premiums and project's overall cost.

The public will get higher quality projects when using prequalification because of all the above mentioned benefits to the owners, contractors, surety companies, and the construction industry.

Despite these benefits, constraints exist that will prevent these benefits from being fully realized, for example

- laws and regulations in many states require contracts be awarded to the lowest responsible bidder, and

- the prequalification system, itself, requires subjective judgment from the contract administrator.

There are some situations where it is not advisable to prequalify such as the following cases:

- specialized projects that require specialized expertise available from only one or two contractors;
- the contract value may be too large for the capacity of the available contractors or vice-versa; and
- the economical market conditions may result in that the available contractors are not willing or able to bid for the project.

Prequalification in the Different State DOT's

All 50 State DOT's were asked, among other things, to complete a questionnaire about their prequalification system. Table 2 contains a summary of prequalification systems used at State DOT's. Twenty-seven of the 40 respondents had used prequalification; one state was considering its use. The remaining 12 State DOT's were not considering using prequalification. Eighteen, of those 27 using prequalification, applied it on all projects. The average satisfaction level among the states using prequalification was high; only two states were not fully satisfied with prequalification. Most of the State DOT's request the same basic information in the prequalification application.

Almost all states agreed that contractor prequalification does not change the following:

- cost of the projects;
- quality of the design;
- cooperation among the owner, engineer, and contractor;
- amount of litigation, claims, and change orders;

- construction cost; and
- project life cycle.

There is a large variance among the different states on the minimum project size on which prequalification is used. Some State DOT's use it on all projects. For other State DOT's, the minimum size project varies from $2,500 to $250,000. Ninety percent of the State DOT's stated that the type of project does not influence the use of prequalification.

Almost every state uses prequalification in one way or another. Most State DOT's request the contractor to complete a questionnaire. Most questionnaires ask for the same basic information, but every State DOT uniquely analyzes the information. Some analyze the information only to calculate the maximum bidding capacity. Some states put higher emphasis on the experience with that State's DOT than with other owners.

Table 2. Content of Prequalification Systems in Various State DOT's

State	Management Experience	Technical Experience	Firm's Experience	Completed Projects	Financial Stability	Equipment	Safety	Drug Abuse	Remarks
Florida	C&U	C&U	C&U	C&U	C&U	C&U	NC	NC	Applicable for project > $250,000
Colorado	C&U	C&U	C&U	C&U	C&U	C&U	NC	NC	
Conn.	C&U	C&U	C&U	C&U	C&U	C&U	NC	NC	
W.Virginia	C&U	C&U	C&U	C&U	C&U	C&U	NC	NC	
Arkansas	X	X	X	X	X	X	NC	NC	
Penn.	C&U	C&U	C&U	C&U	C&U	C&U	NC	NC	
Illinois	C&U	C&U	C&U	C&U	C&U	C&U	NC	NC	List of main suppliers is requested
Texas	N	N	N	N	U	N	NC	NC	List of main suppliers is requested
Nebraska	C&U	C&U	C&U	C&U	C&U	C&U	NC	NC	
Kansas	C&U	C&U	C&U	C&U	C&U	C&U	NC	NC	
Utah	C&N	C&N	C&U	C&U	C&U	C&N	NC	NC	

C&U Collected and Used.
C&N Collected and Not Used.
NC Not Collected.
X Collected, use undetermined.

Formulas to calculate the maximum capacity for contractors varies by state. Generally states calculate a maximum bidding capacity to limit the amount of work a contractor can perform. Unless otherwise stated, for the following formulas, net Bidding Capacity (*BC*) is calculated as follows:

$$BC = C - AU$$

where,

BC = Net Bidding Capacity,

C = Maximum Bidding Capacity,

AU = Awarded and Uncompleted contract work as a prime.

Prequalification in Florida. The Florida DOT calculates the maximum bidding capacity according to the following formula:

$$C = AF \times CR \times ANW$$

where,

AF = Ability Factor varies from 2 to 15 based on

1. the experience of both the contractor's firm and its principal employees in highway and bridge construction,

2. the contractor's experience in non-bridge and non-highway construction, and

3. past performance with Florida DOT. (Florida DOT lays out a detailed scoring system for the contractor's DOT, giving that contractor higher score and ability factor.)

CR = Current Ratio factor = Current Assets/Current Liabilities, maximum possible value for *CR* is 2, CR must be $\geq$ 0.6.

ANW = Adjusted Net Worth (capital and surplus), *ANW* must be > 0.

Prequalification in West Virginia. The West Virginia DOT calculates the maximum bidding capacity according to the following formula:

$$C = AF(A + I + L + E)$$

where,

AF = Ability Factor, ranging from 1 to 10, based on the past performance of the contractor. The maximum ability factor assignable to a contractor with no DOT experience is 5. The factor is increased, decreased, or unchanged depending on the performance of the contractor on the DOT projects;

A = Net current assets;

I = Cash surrender value of life insurance;

L = Line of credit with maximum value of 50% of net current assets; and

E = Book value of the highway and bridge equipment.

Prequalification in Pennsylvania. The Pennsylvania DOT calculates the maximum bidding capacity according to the following formula:

$$C = AF\left(NW + \frac{L}{2} + \frac{E}{2}\right)$$

where,

AF = Ability Factor; ranges from 1 to 15, it varies based on the past performance of the contractor (1 is poor performance),

NW = Net Worth = Current Assets - Current Liabilities.

Other information collected on the questionnaire helps in making a subjective decision regarding qualifying or disqualifying the contractor. If the contractor is qualified and has worked with the DOT, then the ability factor is assigned according to the evaluation report written by the DOT's site construction manager. If the

contractor has not worked with the DOT, the contractor is assigned an ability factor of 5 regardless of the contractor's capability. Every year thereafter, the contractor's ability factor will (a) increase by one point, (b) decrease by one point, or (c) stay the same, depending on the performance of the contractor with the DOT.

The Pennsylvania DOT may temporarily debar any prospective bidder for any of the following reasons:

- unsatisfactory past performance,
- failure to complete a project in accordance to specification and contract,
- default on prior work,
- failure to refund any overpayment,
- bribing or giving gratuities to department employees,
- debarment by Federal or State authorities,
- unbalanced bids, or
- failure to submit documents or forms according to contract.

Prequalification in Texas. The Texas DOT calculates the maximum bidding capacity for contractors by multiplying the working capital by a factor determined by the department. This factor is currently equal to 20, assigned equally to all contractors.

The contractors are not prequalified for specific types of work; they can bid on any project as long as the contract value is within the net bidding capacity. Despite that Texas DOT collects detailed information related to the contractor's past performance and experience, owned and leased equipment, and managerial and technical experience; the DOT does not use this information to qualify the contractors. This application, according to Mr. Scot Nicholas-the assistant manager of the prequalification and proposal department, works for Texas DOT. The default rate of over $2 billion projects is about 1.1%.

Prequalification in Connecticut. The DOT of Connecticut calculates the maximum bidding capacity for contractors using the following formula:

$$C = AF\left(SNW + CSPU + PIC + \frac{EQPC - EQBV}{2} \right)$$

where,

AF = Ability Factor = 10,

SNW = Surplus Net Worth,

CSPU = Capital Stock Paid Up,

PIC = Paid In Capital,

EQPC = EQuipment market value or PurChase price, and

EQBV = EQuipment Book Value.

The net bidding capacity is calculated by the following formula:

$$BC = C - (U + W - S)$$

where,

U = Uncompleted amount(s) of all contracts under construction plus all and pending contract awards as a prime contractor, excluding amount of work subcontracted from other firms,

W = Amount wishing to bid, and

S = Remaining work to be performed by subcontractors including DBE/WBE (Disadvantage Business Enterprises/Women Business Enterprises) set aside percentages, since this work is subcontracted, in this formula is considered Zero.

Two characteristics of the contractor are checked:

1. The financial stability of the contractor is checked to calculate the maximum bidding capacity.

2. Past performance on similar projects is checked to see if the contractor has sufficient experience on similar projects. If the contractor does not have experience in that type of work, the DOT checks the experience of the principal individuals. The contractor will be prequalified if some of contractor's permanent employees have sufficient experience in that type of work.

Prequalification in Colorado. The Colorado DOT does not calculate maximum bidding capacity for a contractor; instead, the department relies on bonding agencies to limit a contractor's maximum bidding capacity. The contractor has to submit required bid and performance bonds of the correct amount with their bid.

The contractor is evaluated on pass/fail basis on a set of criteria including: financial capability, resources, experience, past performance, etc. The department checks the sufficiency of the contractor's equipment, trained personnel, organization, experience, and past performance for the intended type of work. In addition, the financial capability of the contractor is the foundation of the prequalification decision making process. The following financial ratios have to be met to prequalify:

- Current Ratio = Total Current Assets/Total Current Liabilities > 1,
- Cash and Account Receivable/Total Current Liabilities >1,
- Net Fixed Assets/Net Worth < 2.3, and
- Total Liabilities/Net Worth < 4.0.

Colorado DOT is currently considering including the contractor's performance evaluation, conducted by the DOT's Site Construction Engineers, into the prequalification decision-making process.

Prequalification in Illinois. Among all states, the Illinois DOT's prequalification system is the most thorough. IDOT calculates the maximum bidding capacity as the smallest of the Financial rating Capacity (*FC*) and the Work rating Capacity (*WC*):

$$C = \min\{FC,\ WC\}$$

The maximum financial capacity is calculated by the following formula:

$FC = 10(CA + E + RE)$ for Total Assets < \$200,000_
$FC = 11(CA + E + RE)$ for \$200,000 < Total Assets < \$300,000_
$FC = 12(CA + E + RE)$ for \$300,000 < Total Assets < \$200,000_

where,

FC = Maximum Financial Capacity,

CA = Current Assets, and

RE = Real Estate.

The Work Capacity (*WC*) depends on the type of work, relative amount of experience, and equipment resources. The projects are divided into two types: Type I projects include earth work, concrete paving, bituminous plant mix, bituminous aggregate bases and surfaces, and cover and seal coats. Type II projects include the remaining types of highway and bridge works. *WC* for type I projects is calculated using the following primary formulas:

$$WC = PF\left(\frac{EF}{2} + \frac{EqF}{2}\right) \quad \text{when } EF < EqF$$

$$WC = PF \times EqF \quad \text{when } EF \geq EqF$$

where,

PF = Performance Factor, ranges from 1/3 to 1-1/3 based on the following:

- compliance with specification requirements,
- organization and prosecution of work,
- cooperation with the owner,
- traffic control and site protection,
- equal opportunity employment, and
- labor compliance in the projects of the previous year with the DOT or local agencies.

If the contractor has no applicable work experience, *PF* will be equal to 1.

EF = Experience Factor, the dollar value of the total work performed by the contractor in the given work categories for the DOT or an acceptable agency for the DOT.

EqF = Equipment Factor, the annual dollar value of the productive capacity for the selected equipment and plant facilities. Illinois DOT has a detailed schedule to calculate the *EqF*.

For type II works, *WC* is calculated by the following formula. Equipment is evaluated on a pass/fail basis based on its sufficiency and suitability to do the job.

$$WC = PF \times CP \times 1.2$$

where,

CP = Capacity to Perform, the average dollar value of the highest 3 years in the last 10 years in that work category.

If the financial capacity is over $75 Million or the net worth is more than $20 Million and the work capacity is over $20 Million, then the maximum capacity is unlimited.

Conclusions. As a result of the state DOT survey, this research found that state DOT's are determining the qualification of a contractor using three basic criteria: finances, equipment, and past experience and/or performance. Although every state with a prequalification system is asking the contractor for information about all three of these criteria, most states do not use the information in evaluating the contractor's qualification.

Prequalification in the State of Louisiana

Discussion. The 1992 Edition of *Louisiana Standard Specifications for Road and Bridges*, published by LaDOTD, Section 102.01, states the following about "Prequalification of Bidders--To qualify for submission of a bid, the bidder shall comply with all rules and regulations of the Louisiana State Licensing Board for Contractors." In addition Section 102.02 states, in essence, that projects with an estimated cost over $50,000 will be done only by contractors with a license.

To further determine the attitudes and opinions toward prequalification in Louisiana, the research team conducted a survey of the Louisiana highway construction industry through Questionnaires 2, 3, and 4, discussed earlier in this report. The objectives of the survey specifically related to prequalification are:

1. familiarity of the bridge and highway construction industry representatives with prequalification,

2. opinion of the industry representatives in employing prequalification in bridge and highway projects, and in factoring prequalification into the bidding process,

3. the issues that should be considered in the prequalification analysis, and

4. relative importance of each issue in the prequalification system.

Of the 46 engineer respondents, only ten were very familiar with prequalification, 20 were familiar, and 16 were not familiar. Twenty (of 41 constructors) were very familiar with prequalification, 19 were familiar, and only two were unfamiliar with it. Six of the nineteen engineering consultants were very familiar with prequalification, ten were familiar, and three were unfamiliar with it. Figure 2 presents the previous

numbers as the respondents' cumulative percentage of each group versus degree of familiarity of each group with prequalification.

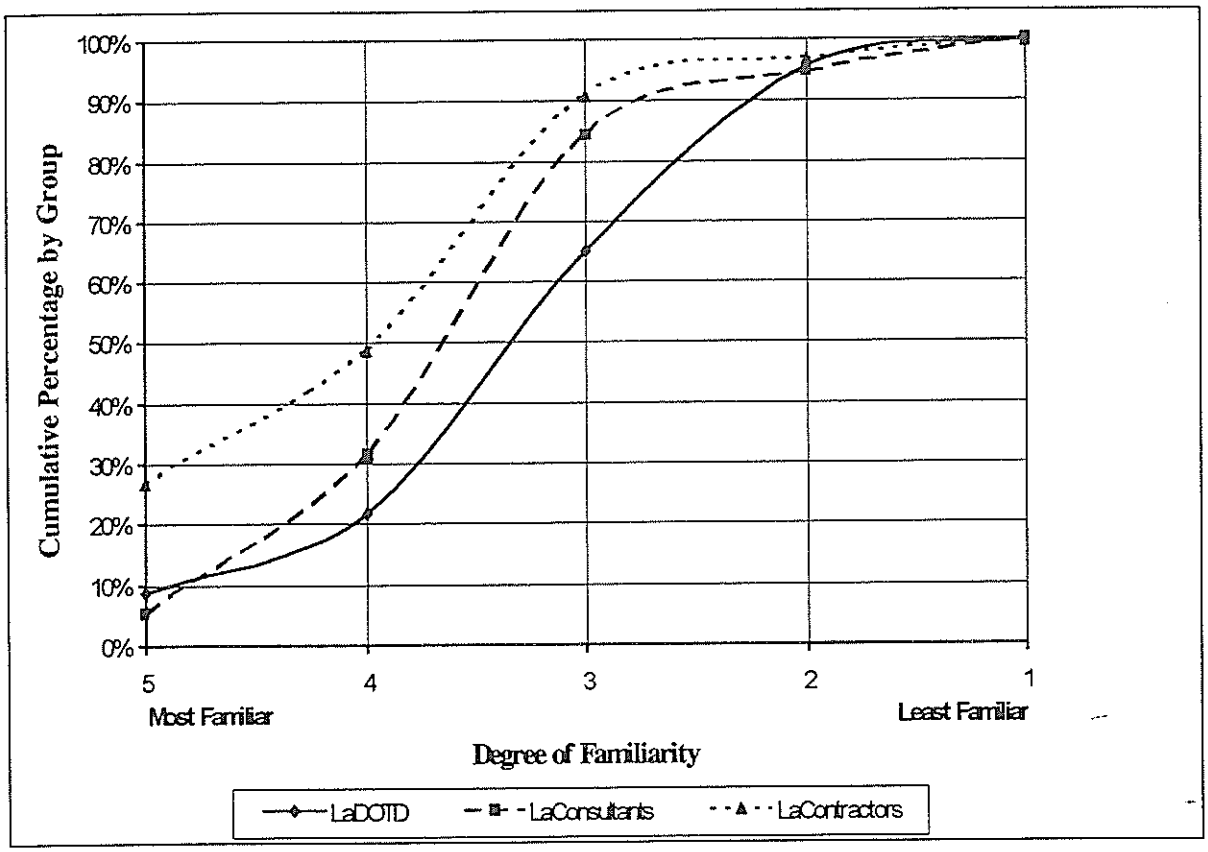

Figure 2 Cumulative percentage of familiarity with prequalification in Louisiana

Twenty-seven (96%) LaDOTD officials supported employing prequalification to rate contractors (see Figure 4), compared to fifteen (79%) of the consultants, and thirty-three (85%) of the contractors. Eighteen (67%) LaDOTD officials supported factoring the prequalification rating into the bid (also in Figure 4), compared to eight (53%) of the consultants, and nineteen (58%) of the contractors.

The respondents were also asked about the criteria to be factored into the prequalification scheme (refer to Figure 3). The top four criteria are: past performance (91%), past experience (76%), status of previous work (72%), and financial stability (68%). The three most important prequalification criteria, according to the Louisiana construction industry are:

LADOTD ENGINEERS	LACONSULTANTS	LACONTRACTORS
past performance	past performance	past performance
experience	experience	safety performance
status of previous work	financial stability	financial stability

According to the Louisiana highway construction industry, the three least important prequalification criteria are:

LADOTD ENGINEERS	LACONSULTANTS	LACONTRACTORS
references	company organization	references
company organization	references	current work load
financial stability	equipment resources	work force resources

Conclusions. This questionnaire helped identify the most important criteria for prequalification of contractors in Louisiana. Respondents indicated that past performance and experience, and the status of previous work should be given more emphasis in a prequalification scheme than financial stability, which is also rated as an important criteria. In addition, barely 50% of respondents indicated equipment resources should be in the prequalification scheme.

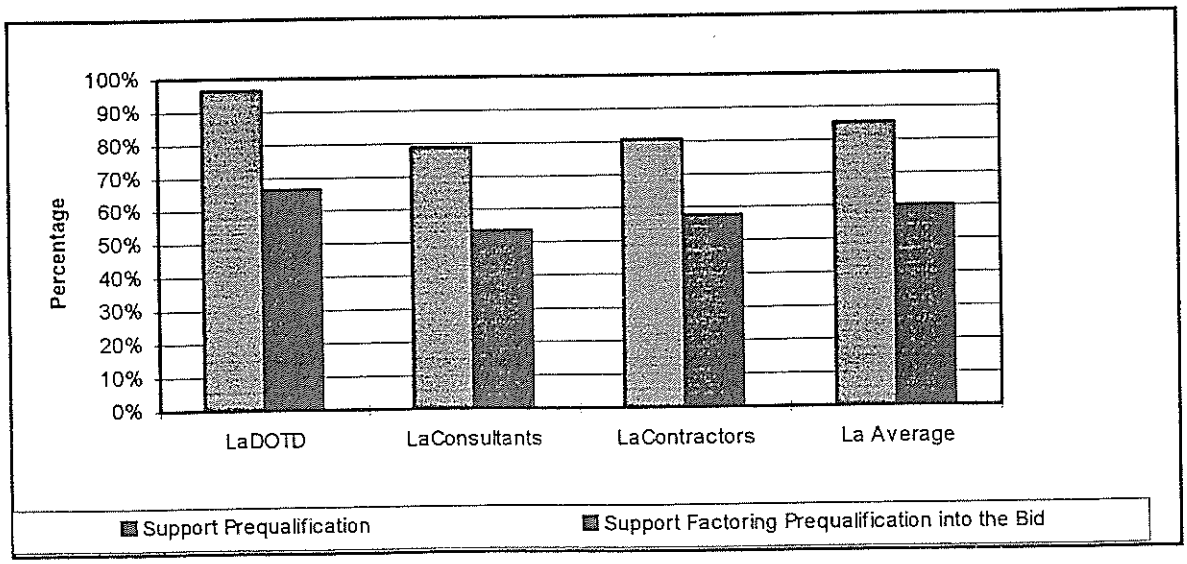

Figure 3 Percentage of respondents supporting prequalification.

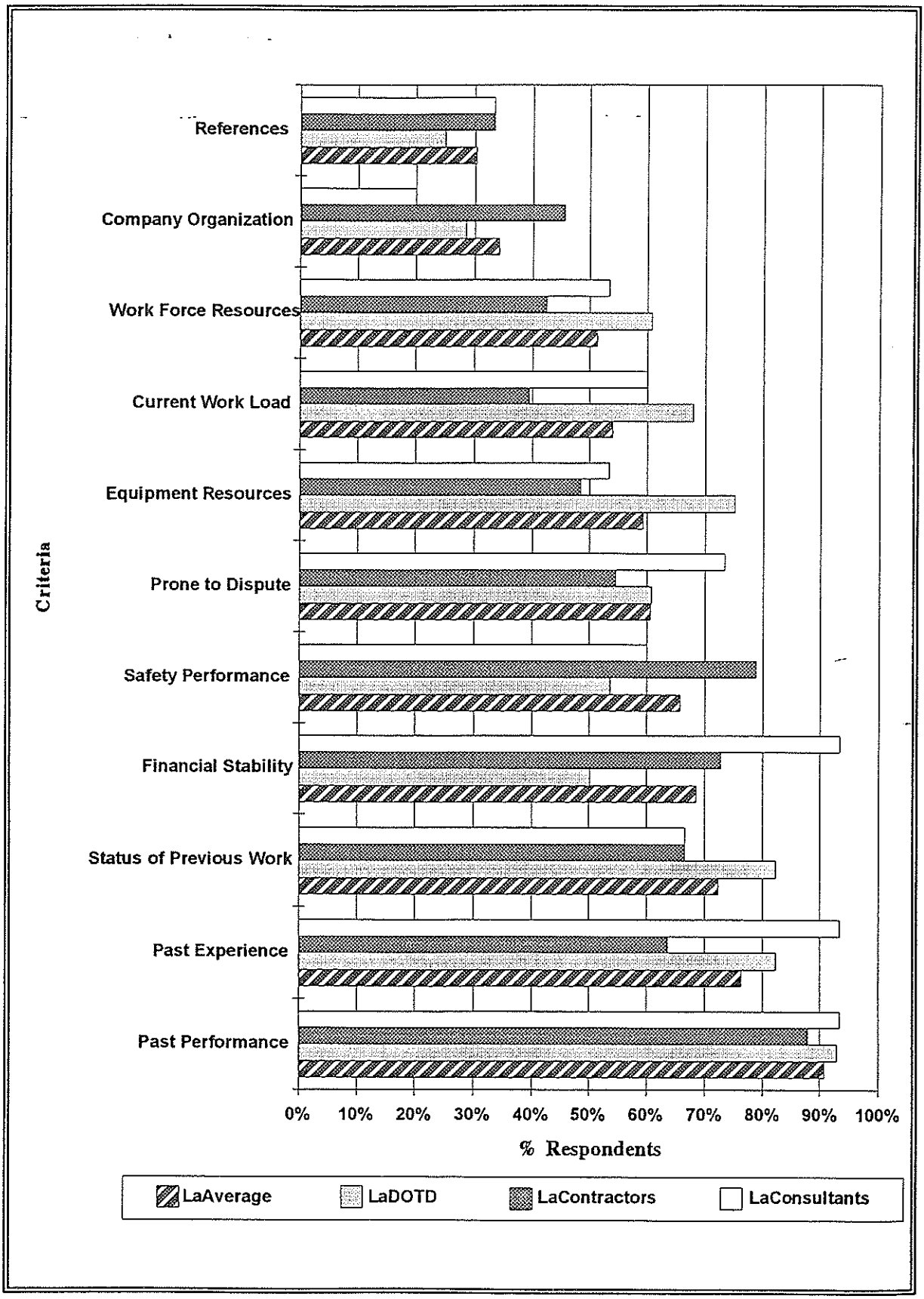

Figure 4 Percentages of Louisiana Highway Construction Industry Respondents Supporting Using Prequalification.

For developing a prequalification scheme, consideration should be given to both what other states are doing and what Louisiana survey respondents indicate should be done Using this premise, we found that three criteria should be measured in a prequalification scheme: finances, equipment, and past experience/performance. Many states currently include finances by measuring relatively objectively criteria provided on the contractors' financial statements. States are also including equipment relatively objectively using information from contractors' records, such as financial statements, and rental records.

Although states ask questions about past experience/performance (PEP), it is not being objectively quantified into prequalification system, due to its subjective nature. However, utility theory can be used to quantify subjective criteria. Utility theory measures the relative importance of contractor attributes, and assigns numeric value to those attributes based on their relative importance to each other.

The Proposed Prequalification System

System Criteria. The following criteria and objectives drove the development of a prequalification system for the LaDOTD:

- create a simple collection and analysis system,
- maintain the confidentiality of information provided by contractors,
- minimize subjectivity,
- robust in ability to handle a variety of cases,
- maintain and encourage competition between contractors,
- allow new contractors to work on LaDOTD projects if they have the required resources to do it and have proven their capability as a subcontractor,
- help contractors to identify their weaknesses to strengthen for future projects,

- discourage disputes with the owner, but do not prevent the contractor from bidding because of past disputes, and

- discourage failure to complete projects, but give the contractors who have failed, due to reasons beyond their control, a calculated chance to bid for projects with LaDOTD.

System Development. Using the discussions with other states and the results of the questionnaire, the research team developed a Prequalification Application, shown in Appendix H. The investigators constructed the questionnaire to measure contractors' financial stability, equipment resources, and past experience and performance. When possible, questions were modeled after those used in other states prequalification systems.

After the investigators created the application, they set out to develop a scheme to analyze the answers to the application. The analysis scheme is designed to measure a contractor's characteristics as follows:

- financial stability is measured using financial ratios calculated from the contractor's financial statement, which are aggregated into a Financial Rating (*FR*);

- equipment capacity is measured using data in the prequalification application; it is aggregated into an Equipment Factor (*EqF*);

- past experience/performance (PEP) is measured using data in the prequalification application; it is aggregated into a Performance Factor (*PF*);

- net bidding capacity is measured by combining the Equipment Factor, Financial Rating, Performance Factor, Net Worth, and Current Work Load.

With the scheme in hand, the researchers developed the method for aggregating information into their respective factors. When possible, the researchers tried to use an aggregation method already developed by another state.

- Financial Rating (*FR*): Our findings indicate that the sureties do a good job of analyzing the financial capability of contractors, so we believe the LaDOTD should minimize its analysis in this area. We believe that the contractors' financial rating can be determined on a pass/fail basis by simply comparing contractors' financial ratios to industry averages. The following ratios are commonly used: quick ratio ([Current Asset - Inventory]/Current Liabilities), current ratio (current assets/current liabilities), net fixed assets/net worth, total liabilities/net worth. Industry averages should be established by LaDOTD for comparison.

- Equipment Factor (*EqF*): Our findings indicate that sureties are not as well qualified as the LaDOTD in determining acceptable equipment resources. So we recommend that the LaDOTD establish an equipment rating scheme, similar to that used in Illinois. We believe that the contractors' equipment factor can also be determined on a pass/fail basis by comparing the contractors capacity to required capacity level. Required capacity levels should be established by LaDOTD based on work type.

- Performance Factor (*PF*): Ten questions in the prequalification application are used to determine the contractors' past performance and experience. To aggregate these variables into one factor, an analysis scheme was created using utility theory. A final questionnaire was created and sent to LaDOTD construction engineers, asking them to provide their opinions on the importance nine of these questions in prequalification. [The two questions on failures (F_O and F_P below) are combined into one factor, only nine questions were included in the questionnaire.] Table 3 summarizes the collected data. The table includes (1) the weight of each criterion from each questionnaire, (2) the average weight, and (3) the 95% confidence interval of the average weight. (Note: 95% confidence interval is defined as the range of values wherein the true mean value has a 95% chance of being found.) The following equation aggregates the application responses based on the final questionnaire's results:

$$PF = 9\times YB + 17\times E_O + 13\times E_P + 11\times NP + 16\times F_O (or 16\times F_P) + 10\times D + 14\times L + 7\times A + 5\times SA$$

where,

PF = Performance Factor, possible values: {0 to 102}.

YB = Years in business factor, possible values: {0 or 1},

E_O = Experience of organization factor, possible values: {0, 0.2, 0.4, 0.6, 0.8, 1.0},

E_P = Experience of principals factor, possible values: {0, 0.1, 0.3, 0.5, 0.6, 0.7. 0.8, 0.9, 1.0}

NP = Completed projects factor, possible values: {0, 0.7, 1.0},

F_O = Failure of organization to complete a project factor, possible values: {0 or 1},

F_P = Failure of principals to complete a project factor, possible values: {0 or 1},

D = Defective work replacement or repair factor, possible values: {0 or 1},

L = Litigation factor, possible values: {0, 0.2, 0.4, 0.8, 1.0}

A = Accident factor, possible values: {0, 0.5, 1.0}, and

SA = Substance abuse policy factor, possible values: {0 or 1}.

- Net Bidding Capacity (BC): Given the foregoing, the bidding capacity equation would have the following form:

$$BC = FR \times EqF \times \left[\left(\frac{PF}{5} \times ANW\right) - AU\right]$$

where,

FR = Financial Rating, possible values: {0 or 1},

EqF = Equipment Factor, possible values: {0 or 1},

ANW = Adjusted Net Worth, taken from the contractor's financial statements,

AU = Awarded and Uncompleted contract work as a prime.

Table 3. Weights in the Prequalification Questionnaire

Questionnaire #	Experience of Organization	Failure to Complete a Project	Dispute or Litigation	Experience of Principal Individuals	Number of Completed Projects	PI's' Failure to Complete (Defective Work)	Years in Business	Safety	Substance Abuse
1	15	20	15	10	10	15	5	5	5
2	15	15	10	10	10	10	10	10	10
3	20	10	5	20	10	10	20	2	3
4	30	10	10	25	5	5	5	5	5
5	5	20	15	10	10	15	5	10	10
6	20	15	15	20	10	5	5	5	5
7	10	15	20	10	10	10	10	10	5
8	5	10	60	4	5	10	3	2	1
9	13	12	15	10	15	10	10	5	10
10	20	15	20	15	5	8	5	11	1
11	11	17	12	14	7	16	8	11	4
12	15	20	10	15	5	15	5	10	5
13	15	20	10	5	15	5	15	10	5
14	50	25	0	0	20	0	0	5	0
15	20	10	10	20	10	10	10	5	5
16	10	15	10	10	20	12	10	7	6
17	20	20	15	20	5	8	10	1	1
18	18	15	20	10	12	2	10	10	3
19	20	15	10	5	15	5	20	5	5
20	10	25	5	10	25	10	10	3	2
21	10	25	5	10	10	20	10	5	5
22	25	10	10	25	2	10	3	10	5
23	15	5	10	15	15	5	15	10	10
24	15	20	20	12	7	11	9	5	1
Average	16.96	16.00	13.83	12.71	10.75	9.46	8.88	6.75	4.67
SD	9.18	5.37	11.13	6.44	5.60	4.69	4.99	3.23	2.99
95% CI, LL	13.76	14.12	9.95	10.46	8.79	7.82	7.13	5.62	3.62
95% CI,UL	20.16	17.88	17.72	14.96	12.71	11.10	10.62	7.88	5.71

SD is Standard Deviation, 95% CI is the 95% confidence interval, LL is lower limit, UL is upper limit.

Information Collection

The information required for prequalification should be collected from several sources, including the following:

- prequalification application,
- evaluation reports written by owners of projects completed by the contractor,
- evaluation reports written by LaDOTD construction engineers about projects completed by the contractor for LaDOTD, if applicable,
- bank with whom the contractor is dealing, and
- material suppliers and subcontractors with whom the contractor is dealing.

Information Analysis and Decision Making

Following collection of the prequalification application, and other needed information on the contractor, analysis occurs according to the prequalification analysis scheme, shown in Appendix I. Prequalification analysis will be administrated by one engineer who has adequate engineering, construction, and managerial experience in bridge and highway work. The prequalification engineer will evaluate the qualification of the contractors using the prequalification scheme.

If the contractor has adequate financial stability and equipment for the work proposed, and the Performance Factor of the contractor is more than 80, a capacity rating should be calculated. If the Financial Rating is 0, or the Equipment Rating is 0, or the Performance Factor is less than 75, the contractor should be disqualified. If the Performance Factor is between 75 and 80, the contractor is in the gray area, and a prequalification committee should be convened for a more in-depth review of the contractor's qualifications. If the contractor is unsatisfied with the decision of the prequalification engineer, the contractor can appeal to the prequalification committee.

The committee will further evaluate the contractor's experience, with each committee member calculating a Performance Rating. The contractor will be

qualified when the majority of the committee qualifies the contractor, and vice versa. The average of the Performance Ratings, calculated by the committee members, will be used in calculating the maximum bidding capacity of the contractor.

The prequalification committee should consist of three experts from the owner's organization. The number of the members of the committee is recommended to be three to

1. minimize the subjectivity and increase the objectivity in making the prequalification decision,

2. reduce the opportunity for human weakness from abusing the prequalification system, and

3. reduce the cost of operating the system.

Case Scenario Analysis

In a modest attempt to test the Performance Rating values, a simple in-house analysis was conducted. The case study evaluated the reasonableness of the Performance Rating value using seven different cases, detailed below. During the case analysis, the Performance Rating value was checked based only on the experience and judgement of the research team; due to the limitations in scope of this research, no external validation was conducted. The analysis helped the research team establish cut-off scores, and evaluate the potential consequences of employing the system in the different situations. Appendix J presents the results of the analysis.

Conclusions. Although prequalification has many advantages for the entire construction industry, it must be properly implemented to prevent:

(a) employing a contractor that should be disqualified; and/or

(b) disqualifying a contractor that could be employed.

- The objectives of surety firms in studying the qualifications of contractors are different from, and may not be consistent with, those of the owner. The surety firm checks the ability of the contractor to indemnify itself if the

contractor fails to complete the job. The owner, on the other hand, checks the ability of the contractor to complete the project without failure or dispute and within time and budget.

- Surety underwriters do not follow consistent techniques to evaluate a contractor's qualifications, but rely on their experience and judgment. As a result, it is possible that two underwriters can disagree on qualifying contractors.

- The bridge and highway contractors in Louisiana are more familiar with prequalification than the consultants who are more familiar with prequalification than LaDOTD engineers. 81% of the contractors in Louisiana, who responded to the questionnaire, support application of prequalification and 57 % of them support factoring prequalification in the bids.

- The proposed prequalification system screens the contractors based on three major criteria: experience, resources, and financial stability.

- The objectives of the proposed prequalification system are simplicity, objectivity, flexibility, and fairness. It also gives new contractors, who have employees with adequate technical and managerial skills, the opportunity to bid on a job after completion of similar projects. In addition, it highlights the weakness of the contractors, discourages dispute, and maintains the confidentiality of the information. Also, the prequalification system does not reduce competition.

Design/Build

The Design/Build (D/B) concept arose from the owner's desire to have a single-point of design and construction responsibility, and to eliminate the finger-pointing battle that often occurs between the construction contractor and the designer (16). When using this concept, one contract is awarded for both the design and construction; hence one entity provides both design and construction for the owner (16). Researchers have identified four critical success factors that must be met for a design/build project to be effective. These factors include a well-organized team, a series of contracts that eliminates conflicts of interest, experience in all phases of similar projects, and communication between all parties involved (17).

The design/build concept has recently gained a substantial amount of credibility. One source stated that $71-billion, nearly one-third of the Top 400 Contractors contract volume for 1993, was awarded as design/build projects (18). The United States Postal Service is one of the major supporters of this concept. Design/build has been its method of construction since 1989 because design/build projects are easier to manage. More activities can be completed in parallel and the Postal Service does not have to act as the referee between the construction contractor and the designer (18).

The reason for the drastic increase in the use of this concept is its various advantages. As already mentioned, one of the largest benefits of design/build is the less adversarial relationship between the designer and the construction contractor. Since they are on the same team (and in order to make a profit) they must work together (19). Since a single contract is awarded, the contractor cannot argue that any faults are due to the designer. Likewise, the designer cannot blame the construction contractor for any defects in workmanship. McManany (18) reports that "Design/build eliminates 98% of the finger-pointing that results in litigation." Another positive aspect is the time savings that results. Since the owner is able to select the designer and the contractor at the same time, work can be started when the design is 30 to 40 percent complete. Additionally, any changes in the design plans that may need to be made do not take as long to address. The Florida Department of Transportation has reported a time savings of 10 to 48 percent with little additional costs (20).

Before design/build can be implemented, several obstacles must addressed. The Brooks Act states that a design professional cannot be awarded a contract based solely on low bid. However, under the public bid law, a contractor must be awarded a contract on the basis of low bid (4). Therefore, there is some controversy as to whether or not this concept is legal. Many government agencies who have used the design/build concept have developed a legitimate compromise between the two laws (21). However, if a contract is not awarded to the lowest bidder, substantial reasons must be given (21). Another disadvantage of the concept is that the submittal of the preliminary design proposals results in costs and loss of time to all non-successful bidders (18).

Dispute Review Board (DRB)

A dispute review board consists of a "neutral" committee that regularly monitors the project job site for possible causes of disputes. The DRB resolves disputes as they occur before adversarial attitudes grow (22). The key to accomplishing this is to move away from the traditional adversarial relationship between the granting authority and construction contractor toward a more cooperative relationship. People who serve on the DRB should be knowledgeable in the entire construction process (23).

DRB's were introduced on the second bore of the Eisenhower Tunnel from 1975 to 1979. As a result, this concept typically has only been considered for underground construction. In the mid-80's, due to the rise in the cost of litigation and delays, the U.S. Army Corps of Engineers began to consider alternatives to solving disputes. After much study, alternative dispute resolution (ADR) methods appeared to be the answer (22). The first ADR to be implemented was the mini-trial. However, because the number of contract cases continued to rise, the Corps began to try other dispute resolution methods. These methods include: Non-binding arbitration, dispute review boards, and mediation (22). This and continued experience has proven that dispute resolution boards are beneficial to all types of construction (23).

The principal advantage of dispute review boards is that problems can be solved at the job site level before they become formal claims or lawsuits. Litigation invokes a "win-lose" attitude and destroys the possibility of a cooperative non-adversarial relationship between the owner and the construction contractor (24). Since the board is competent and has no vested interest in the outcome, disputes are resolved objectively and promptly. Therefore, there are fewer disruptions and management spends less time defending litigation. In addition, the cost of a DRB is mild compared to the expense of litigation (24), therefore minimizing legal costs and time. A recently published ASCE pamphlet (25) showed that, in virtually every DRB project, the parties of the contract solved all the problems at the job site level. There were no additional costs for litigation, arbitration, or legal fees.

The recommendations that the DRB makes may or may not be legally binding (23). If they are not binding, the parties do not have to accept the recommendation, leaving the dispute unresolved. According to one study (23) however, as of June 1993, there have been no cases where the DRB recommendations have not been accepted by both parties. Another problem with DRB'S is that construction

contractors may be encouraged to take problems that would not ordinarily cause conflicts to the dispute review board in hope of getting partial compensation. Additionally, when problems are resolved, the monetary solution recommended by the DRB is often based purely on compromise instead of on real values.

Guarantee/Warranty

A guarantee/warranty is an assurance by the construction contractor that the final product will meet all specified requirements for a specified given period of time after the final inspection and/or approval. Traditionally, the use of warranties in highway construction in the United States has been limited to electrical and mechanical equipment and maintenance since federally funded projects could not include guarantees or warranties. However, the success of warranties on non-federal projects and projects in other countries prompted the United States government to further study this concept. During consideration of the Intermodal Surface Transportation Efficiency Act of 1991, an amendment was proposed which would allow the use of warranties on federally funded projects. Although this amendment was defeated, a conference committee was composed to address improving the quality of highways (26).

The use of guarantees and warranties are common for a period of one year after completion of a project. However, long-term warranties, which cover two to five years, may result in many benefits. Quality of the final project is generally increased with the use of guarantee/warranties because the contractor is responsible for any latent defects (26). If contractors are responsible for the final product, they have a financial incentive to build a better product. Improved quality, in turn, will reduce the life-cycle costs (27). In addition to improving quality, guarantee/warranty provides assurance to the owner that any early failures due to materials or workmanship will be corrected at no additional expense (26). This would be true regardless of inspection and approval.

Every project owner wants improved quality but guarantee/warranty may not provide the vehicle to obtain it. The major obstacle is that the owner will not be able to enforce a guarantee/warranty if the contractor has built the product according to the specifications (27). If the reason of failure cannot be attributed to the contractor, then the contractor cannot be responsible to repair or replace the failure. Misunderstandings on what is and what is not expected may lead to many problems and may possibly increase litigation (26). To make matters more complicated,

factors such as traffic volume, weather, and regular maintenance greatly effect the performance of highway structures. If these factors differ from the design criteria, failure of the product is not due to improper construction. Therefore, these and other such factors must remain constant before the construction contractor can be held responsible (27).

Incentives/Disincentives

General

The Incentive/Disincentive (I/D) concept is a way of trying to bring the owner's and contractor's objectives into alignment with each other. This concept provides the contractor with increased compensation (incentives) for reduced project duration or increased quality, and with decreased compensation (disincentive) for increased project duration or reduced quality. I/D's can be provided for cost, schedule, quality, and/or safety. Time-based I/D's provide bonuses for attaining contract time objectives and deductions for not attaining those objectives. Quality-based I/D's provide bonuses for enhanced quality, and deductions for lower, but acceptable, quality.

I/D's are finding widespread use because incentives encourage positive actions, behaviors, and relationships. Part of the reason for this is that the contractor's energies are directed toward developing more effective ways to achieve the project's objectives (28). Additionally, incentive plans require the owner to more clearly define and explain the objectives (28). When the incentive is a high monetary reward, the contractor will place more attention on the project and use the most qualified personnel to perform the work. Decreased construction time and increased quality have also been noticed on I/D projects.

Disincentives (negative incentives) often create a defensive attitude in the contractor because the contractor tends to focus on avoiding penalties rather than achieving project objectives. In addition, contractor personnel encounter added stress on I/D projects. Some contractors testify that they spend their entire bonus getting the job done early (29). Although the most qualified personnel may be working on the project, fatigue may cause a decrease in quality and safety that lessens the effectiveness of the incentive. Contractors may be prone to disagree with the days that are charged and less willing to concede to plan changes by the owner. Therefore, the already existing adversarial relationship between the owner and the contractor may worsen.

Unlike time I/D's, quality I/D's face the dilemma of not having clearly defined objectives. Currently, methods for measuring quality are insufficient to accurately determine the quality of many products. In addition, contracts with I/D clauses appear to have stricter enforcement and greater disputes (30).

Time Incentives/Disincentives

Cost Plus Time and Lane Rental are two concepts typically used as contract time I/D's. Both involve the calculation of a user's cost, which is the cost of inconvenience to the users of the facility, i.e., the traveling public, surrounding businesses, and the surrounding community.

Users' Cost Calculations. Many variables could be included in the calculation of users' cost, for example:

1. Costs due to delays to traveling public,
2. Costs due to increased traveling distance,
3. Costs due to construction-related traffic safety and accidents,
4. Costs due to construction-related traffic maintenance,
5. Costs due to lost business revenue, and
6. Costs due to environmental impact.

However, [3], [4], [5], and [6] are rarely incorporated into the users' cost calculation because of the difficulty in assigning a value to them. Also, the FHWA does not consider impact to surrounding businesses and the environment to be road-user costs, and therefore does not allow inclusion of these values in projects involving federal funds.

Most owners base their Users' Cost on equations with the following general form:

Total Daily Users' Cost, U:

$$U = C + T,$$

where,

C is Total Cars' Cost/Day:

$$= \left\{ \left(\frac{CarCost}{Vehicle-mile} \right) (\Delta miles) + \left(\frac{CarCost}{Vehicle-minutes} \right) (\Delta minutes) \right\} \left(\frac{Number\ of\ Cars}{Day} \right)$$

T is Total Trucks' Cost/Day:

$$= \left\{ \left(\frac{TruckCost}{Vehicle-mile} \right) (\Delta miles) + \left(\frac{TruckCost}{Vehicle-minutes} \right) (\Delta minutes) \right\} \left(\frac{Number of Trucks}{Day} \right)$$

where,

Car Cost/Vehicle-mile, *Truck Cost/Vehicle-mile*, *Car Cost/Vehicle-minute*, and *Truck Cost/Vehicle-minute* represent typical user's costs:

Car Cost and *Truck Cost* includes the following: overhead, taxes, maintenance, insurance, fuel, etc, and *Car Cost/Vehicle-minute* and *Truck Cost/Vehicle-minute* include lost wages of drivers;

Δ Miles = the difference between the normal miles of the road and the detour;

Δ Time = the difference between the amount of time it takes to travel the normal road as opposed to the detour road; and

Number of Cars/Day or *Number of Trucks/Day* can be obtained from average daily traffic (ADT) counts.

Typical values for are *Car Cost/Mile*, *Truck Cost/Mile*, *Car Cost/Minute*, and *Truck Cost/Minute* are shown in Table 4.

Although many states use some form of the equation given above, many states do not because of the inability of the equation to handle variations in traffic flow during the day. Time delays in traffic flow can be better estimated using traffic simulation models. Two computer programs, which combine the above user's cost equations with a traffic simulation model. have been written by the Texas Transportation Institute; these programs are called HEEM-III and QUEWZ.

Table 4. Typical Values for Use in Users' Cost Calculations.

Variable	Cost†	Source
Car Cost/Vehicle-mile	$ 0.25	Federal Information Center
Truck Cost/Vehicle-mile	$ 0.70	Davison Transport, Inc.
Car Cost/Vehicle-minute	$ 0.18	Louisiana Labor Department
Truck Cost/Vehicle-minute	$ 0.19	Louisiana Labor Department
†Note: The research team has verified that these values are approximately equal with other states that use user's costs.		

To properly use users' cost, the value must be carefully determined and the calculation carefully documented. Arbitrary and capricious values will not stand scrutiny in the legal system. Also, users' cost should be distinguished from stipulated damages, which usually are considered to be the owner's construction administration costs. The users' cost value also must be set high enough to compensate the contractor for additional expenses (ΔE) incurred by expediting the project. These additional costs can be represented mathematically as:

$$\Delta E = \frac{F}{t_D} + D$$

where,

ΔE = Total additional construction cost to expedite the project,

F = Fixed, one-time costs for extra materials, equipment, and work force needed to expedite the project,

t_D = Time (in days) by which the contract will be shortened by expediting the project, and

D = Daily costs for extra equipment, materials, and work force needed to expedite the project.

Following is an example calculation of Users' Cost, using the equations and values given above. The calculations are made for a possible Louisiana method, and compared with methods in Idaho and Kansas.

GIVEN:

Average Daily Traffic:		Change in Time:	Change in Distance:
Total	12,400	6.29 minutes	2.5 miles
Cars	11,160		
Trucks, 10% × ADT	1,240		

CALCULATIONS:

Variables	Proposed La. Method		Idaho Method		Kansas Method	
Cars:	Unit Cost	Cost/Day	Unit Cost	Cost/ Day	Unit Cost	Cost/ Day
Time (Cost/vehicle-minute)	$0.06 †	$4,212	$0.15	$10,529	$0.00	$0
Distance (Cost/vehicle-mile)	$0.25	$6,975	$0.00	$0	$0.22	$6,138
Total Cars' Cost/Day:		**$11,187**		**$10,529**		**$6,138**
Trucks:						
Time (Cost/vehicle-minute)	$0.19	$1,482	$0.30	$2,340	$0.18	$1,404
Distance (Cost/vehicle-mile)	$0.70	$2,170	$0.00	$0	$0.71	$2,201
Total Trucks' Cost/Day:		**$3,652**		**$2,340**		**$3,605**
TOTAL DAILY USERS' COST:		**$14,839**		**$12,869**		**$9,743**

†Cost per vehicle-minute is based on the average wage in Louisiana multiplied by an Employed Drivers Factor, which is the percentage of drivers on the road during the day that are actually earning wages or salary, i.e., these people are "on the clock." Assumed to be 33.3%.

Notice that the Users' Cost for the proposed Louisiana method is higher than both Idaho and Kansas. The reason for this is that the Louisiana method assigns a value to each of the four possible areas: Car Time, Car Distance, Truck Time, and Truck Distance. The other states assign values to some of the areas. Idaho does not assign value to the added distance of the vehicles; Kansas does not assign value to the Car Time variable.

Cost Plus Time. The purpose of cost plus time (often called the A + B Method) is to reduce the inconvenience and user's cost. By factoring time into the bid, the owner is able to minimize the time necessary to complete the project. In a Cost Plus Time contract, contractors submit proposals that consist of both a construction bid price (*A*) and a construction bid time to complete the project (*Bid Days*). Prior to bidding, the owner determines a *daily users' cost* by considering all the previously discussed factors. The "basis of award" for each contractor is determined by the following formula:

Basis of Award = *A* + *B*, where

B = *Bid Days* × *Daily Users' Cost.*

The contract is awarded to the contractor with the lowest Basis of Award. At the end of the project, the final contract amount is adjusted up or down depending on the finish time: If the actual construction time is less than the number of bid days, the contract amount is increased using this equation.

(*Bid Days* - *Actual Construction Time*) × *Daily Users' Cost.*

If the actual construction time is greater than the number of bid days, the contract amount is decreased using the same equation.

I/D's are typically included with A + B method by awarding the contractor for early completion or charging him for late completion. By doing so, contractors are discouraged from overrunning the time "bid" for the project (31). In theory, the potential for additional compensation enhances the contractor's motivation, which influences performance (28). The value of the I/D is set equal to the user's cost.

Lane Rental. Lane Rental is a procedure where the contractor is assessed a rental charge, based on a user's cost, for each lane and/or shoulder closure, or other obstruction from the time of "notice to proceed" until the project is complete or the lane is opened. The purpose of Lane Rental is to encourage the contractor to minimize traffic disturbances and restrictions by scheduling work during off-peak traffic hours.

The rental rate is calculated similar to the predetermined user's cost in A + B. The rental amount is stated in the bid proposal in dollars per lane per time period, which could be day, hour, or fractions of an hour. Rental rates vary based on the number and type of lanes closed, and on time of day. For example, high traffic periods, say from 6:30 a.m. to 9:00 a.m. and 3:30 p.m. to 6:30 p.m. would have a higher hourly rate than off-peak periods, and late night hours could have yet another rate, etc.

Lane Rental projects implemented to date have not typically indicated how long the rental will last. The contractors simply accounts for the charge in their bids, and the low bidder is calculated solely on prices bid for construction. Then, during the construction period, the lane rental charge is determined by the owner and is deducted from the monthly progress payments.

Quality-Based Incentives/Disincentives and Performance-Related Specifications

Quality-based I/D are part of the more broadly used term: performance-related specifications (PRS). PRS incorporates a variety of specifications, including:

- *end result*, specifications that focus on measurable attributes or properties of the end products, rather than on the construction techniques and materials used;
- *statistically-based*, specifications that consider the variability of construction techniques, materials, and sampled and final products;
- *performance-modeled*, specifications that focus on performance attributes or properties of the final product using validated models and relationships; and
- *adjustable payment*, monetary increases and decreases made to the contractor for higher or lower value than specified in the final product, more commonly known as "incentives" and "disincentives."

In a more narrow sense quality-based I/D stipulate characteristics of materials and construction quality that correlate with performance, testing, added value, and adjustable payments for a final product (32). These combined elements give the

contractor latitude in construction, and the owner latitude in inspection and approval.

Gaining acceptance and use, quality-based I/D used with PRS are proving to be beneficial to the owner and the contractor (27).

1. From the owner's viewpoint, quality-based I/D enhance the owner's goal for obtaining a facility that operates correctly, withstands the expected use, and can be properly maintained (27). This is achieved because the owner spends less time and effort in defining explicitly the procedure for construction, allowing the owner to focus on testing and approvals.

2. The owner has the ability to pay the contractor a higher or lower percentage of the bid price. This I/D is built into the construction contract and specifications based on the quality of the finished product as compared to the initial requirements.

3. The owner often receives a higher quality product because the contractors are more apt to exceed the minimum standards set forth in the bid documents (32).

4. Contractors also benefit because this concept gives them more responsibility for the quality of the final product, thus giving them the freedom to select the material and method of construction. This freedom motivates the contractor (a) to choose the construction materials and techniques that are most appropriate, and to find and try new techniques that add badly needed innovation to the US construction industry.

Even though quality-based I/D's include many benefits, they still meet much opposition as well as face severe limitations to their full implementation. Some of the opposition stems from the conflict between the owner and the contractor when determining what meets and exceeds the initial requirements of quality in the specifications. This lack of requirements stems from the fact that acceptance tests have not been correlated with long-term liability and/or performance. There is also difficulty in setting a construction price (short-term) that relates to reduced or enhanced life-cycle value (long-term) (32). Currently, little research has been done to accurately relate construction procedures with long-term construction quality. For

this reason, the owner may find it hard to apply these specifications (33). In addition, contractors should have the technical engineering and design training and skills to select materials for the project that will meet the final product performance requirements.

Partnering

In the past, a person's word was his bond. People were willing to accept responsibility for their work (34). Through many claims and litigation an adversarial relationship developed between the LaDOTD and contractors. It is the objective of partnering to minimize this adversarial relationship and obtain a more cooperative atmosphere (35). Partnering refers to a relationship between the owner and the contractor that includes the elements of long term commitment to each other, mutual goals, and trust among participants (35). The purpose of partnering is to minimize the adversarial relationships that often occurs between the owner and the contractor. In this way, the lines of communication are open, working is enhanced, and quality is improved. This approach is typically voluntary (36); it is not contractually binding, but is a mutual agreement between the parties (35,37). It implies that the participants will share risks and responsibilities of the project.

The primary elements of partnering are: commitment from all parties to making the partnership work, commitment to fair and equal treatment of all parties, and trust between the parties (35,36,38,39). The process of partnering begins with a partnering workshop. The workshop includes all key personnel from both the owner and the contractor. The purpose of the workshop is to discuss the objectives of both parties in order to form mutual objectives (36). Individual concerns and possible problems are discussed as well. The intent is to resolve these concerns before conflict develops (40). However, it is inevitable that unforeseeable problems will arise during construction. Partnering provides a clear systematic approach to dispute resolution, and guidelines for moving unresolved issues from one level to the next are clearly defined (41). It is necessary to develop this system before construction starts so that disputes may be resolved as they occur. Quick resolution is essential in order to prevent attitudes from fostering, disrupting the partnership. It is not the intent of partnering to alleviate disputes during construction. Partnering should however, provide a communication process that is effective in dealing with them. In order to enhance the partnering relationship all participants should review and evaluate the process periodically (35). This helps the participants to recall the relationships and attitudes created at the workshop. Therefore, adversarial

relationships are less likely to develop (39). Another benefit to this periodic evaluation, is that it keeps the project on its main objective. Participants are forced to look back at the project goals and assess the project in relation to those goals (38,39).

Partnering brings about many benefits (42). Adversarial relationships typically begin because of a lack of communication, but through partnering, communication is improved. Concentration is placed on teamwork rather than on competition. This helps both parties feel comfortable in the working relationship and resolving discrepancies. Many other factors receive benefit due to the increase in communication. The contractor often reduces his costs through higher productivity and efficiency (43). We have also found, through conversations with state DOT's, that owners profit from partnering. Litigation is reduced because problems that arise are resolved more quickly and at the project level. Through the initial meeting, objectives are clearly defined therefore better quality products are produced.

Since partnering is a concept based on theory, problems are inevitable when the concept is implemented. True commitment is often hard to obtain. Both the owner and the contractor take a great deal of risk in trusting the other party.

Subcontractor/Supplier Approval

Just as the title implies, subcontractor/supplier approval is a concept where the owner preapproves or prequalifies subcontractors and suppliers on a project. This concept is similar to and is repeatedly used in conjunction with "contractor prequalification." Here, the owner rates all subcontractors and suppliers on the basis of past experience, past performance, and/or financial stability.

By preapproving subcontractors and suppliers, the owner tries to make certain responsible and adequate organizations to perform the work or supply the proper materials (44). Since all subcontractors and suppliers that are eligible to provide services for a project must be approved, the owner may be confident that competent parties will provide the proper materials and workmanship are incorporated into the final product. This will ultimately improve the quality of the product. Subcontractor/supplier approval may include approving all contractors and suppliers at the opening of every job, or keeping preapproved subcontractors and suppliers on a job order contract. A built-in incentive helps improve the quality since the

contract is withstanding as long as the subcontractor/supplier continues to produce adequate quality products, materials, and services (1).

Implementing subcontractor/supplier approval may be more difficult than it may seem. A major question that is raised is; "Who does the subcontractor/supplier work for?". Since the prime contractor pays the subcontractor/supplier and the LaDOTD rates them, subcontractors and suppliers are caught in a tug-of-war. If subcontractors/suppliers comply with the project owner but in doing so oppose the prime contractor, he may not be paid for his work. On the other hand, if the subcontractor/supplier succumbs to the prime contractor but fails to meet the owner's requirements, he may not be approved for other construction projects. In either case, the subcontractor/supplier loses (45).

Currently, Louisiana has a qualified products list that includes materials that are appropriate and only items included from this list are acceptable. Subcontractor/supplier approval would possibly extend this list to include organizations that produce top quality products and services. Appendix K contains a preliminary version of a document that the research team is devising for prequalification of contractors and subcontractors.

Value Engineering/Construction

Value engineering as used in this report is a concept that allows alternate designs, construction procedures, or materials to be considered PRIOR TO THE NOTICE OF BIDDING, in order to consider other more economical, or more constructable, or more maintainable options (4). If any alternatives are suggested, the engineer must evaluate them to determine if they are acceptable and beneficial.

A similar concept, called Value Engineering Construction Proposal, is currently used by LaDOTD. Under this concept, contractors are allowed to develop and submit alternate designs, construction procedures, or materials in order to reduce the overall lifetime costs. If any alternatives are suggested, the engineer must evaluate them to determine if they are acceptable and beneficial. It simply gives everyone who works on a project the opportunity to provide input on cost saving ideas. The savings that are produced through value construction are usually shared equally between the owner and the contractor (4).

Value engineering and value construction is becoming more widely used because of their vast benefits (45). The most significant of these benefits is the large savings in cost. Both parties agree to use value engineering and value construction because they both profit from it. It is very likely that construction contractors will provide valuable input on practicality that may have a high monetary reward. The alternatives allow more to be achieved from financial resources without reducing quality, reliability, or safety. This is assured because it is the owner's and engineer's responsibility to thoroughly check the options (45).

Allowing contractors to give alternatives to a design may cause problems, however. These alternatives may be another source for disputes if the alternative is not clearly defined. There is a strong possibility that the owner will misunderstand what the contractor is willing to do or what it will cost the contractor to perform the task. Disputes have also originated when the owner rejects the alternative but later employs another construction company to perform the alternative concept (4). Another facet that must be identified is the timing of approval. All suggestions must be evaluated promptly or the alternate may loose its cost effectiveness.

Some Statutory Considerations[1]

Existing Statutory Impediments to Use of Innovative Contracting Techniques by LaDOTD

As a state agency, the contracting authority of the LaDOTD is a direct delegation of the Louisiana legislature in Louisiana Statutes Annotated and Revised Statutes (LSA-RS) 48:21, 22, 34. The legislature has defined the conditions upon which it will permit public work to be done on its behalf and on behalf of its political subdivisions in the Public Bid Law in LSA-RS 38:2212 and following.

> "LSA-RS 38:2212 (A) (1) (a). All public work exceeding the contract limit as defined herein, including labor, materials, and all purchases of materials or supplies exceeding the sum of five thousand dollars to be paid out of public funds, to be done by a public entity shall be advertised and let by contract to the *lowest responsible bidder* who had bid according to the contract, plans, and specifications as advertised, and no such public work shall be done and no such purchase shall be made except as provided in this Part."

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[1]This section written by Kimberly O. Golden, Attorney at Law, Shafto and Ashbrook, Monroe, Louisiana.

LaDOTD is not exempted from the statute and therefore has no authority to take any action which is inconsistent with the Public Bid Law. (See generally, *Badon's Employment, Inc. v. Smith* (46), holding conduct which contravenes a prohibitory law void and producing no legal consequences). Many of the innovative contracting techniques vary significantly from the procurement scheme embodied in the Public Bid Law.

Pre-qualification of Bidders Prohibited Under the Public Bid Law.

The Louisiana Supreme Court addressed the issue of contractor pre-qualification in *Louisiana Associated General Contractors, Inc. v. Calcasieu Parish School Board* (47) and found it inapposite with the Public Bid Law.

> "There is no legal authority requiring or allowing a responsibility determination to be a precondition to bidding on public contracts. Absent statutory law authorizing the "prequalification" of bidders, we refuse to allow a public entity to engage in a process which eliminates certain bidders from competing before the bidding process ever begins." (47, p. 1364)

The court's analysis in this case (47) is instructive because it encompasses a review of the specific prohibitory provisions in the Public Bid Law and in the Closed Specifications Statute which supplements the low bidder statute. The court concluded the "statutes clearly demonstrate a conscious effort on the part of the legislature to assure uninhibited competitive bidding." (47, p. 1364)

Although it found bidder pre-qualification inconsistent with the statutory scheme and the legislative intent to assure uninhibited competition, the court recognized some flexibility in the statute to permit consideration of factors relevant to the quality of the contractor's performance.

> "The term "lowest responsible bidder" does not constrain the public authority to accept the lowest monetary bid. *Haughton Elevator Div. v. State Division of Administration,* 367 So.2d 1161 (La. 1979)[2]. Rather the Public Bid Law vests the public entity contracting the work with wide discretion to determine bidder responsibility. *Id.*[3] In determining bidder responsibility, the public entity may

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[2]Reference is to *Haughton Elevator Division versus State Division of Administration*, Volume 367, *Southern Reporter, 2nd Series*, p. 1161 (Louisiana Supreme Court 1979).

[3]*Id.* means previous citation.

look to financial ability, skill, integrity, business judgment, experience, reputation, quality of previous work on contracts, and other similar factors bearing on the bidder's ability to successfully perform the contract. *Housing Authority of the City of Opelousas, Louisiana v. Pittman Construction Co., Inc.,* 264 F.2d 695, 698 (5th Cir. 1959)[4]. . . .

> "By enacting the Public Bid Law, the legislature has developed a rather complex and unique procedure by which public entities award public works contracts. Central to this process is the legislature's desire that all prospective bidders be given an opportunity to bid on a given project. In choosing the term "lowest responsible bidder," the legislature sought to further the goals of the Public Bid Law (insuring competitive bidding and protecting the tax-paying citizen from increased costs resulting from fraud and favoritism) while at the same time expressly providing public entities with a mechanism to insure the skill and quality of the workers employed on the project." (47, p. 1362-63)

In this case the court was considering an attempt by the Calcasieu School Board to require bidders to certify to the payment of prevailing wages as a formality in the bid process. In considering this requirement a prohibited pre-qualification the court noted there existed no causal connection between higher wages and better-quality performance. *In dicta*, the court seemed less offended by the notion of qualifying the bids received as "responsible" based upon factors reasonably related to the quality of performance (47, p. 1365).

Post-bid Disqualification Must Satisfy Requirement of Procedural Due Process.

The Louisiana Supreme Court has held the Public Bid Law to create a protected interest in the lowest responsible bidder to receive the advertised contract, if any is let as a consequence of the bidding (48). This interest is encompassed by the protection of the Fourteenth Amendment to the United States Constitution and may not be abridged without due process of law (48). Due process is afforded when the holder of the interest receives notice and an opportunity to be heard before suffering deprivation. The type of hearing required depends upon a balancing of the private interests being protected and the precise nature of the government function

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[4]Reference is to p. 698 of *Housing Authority of the City of Opelousas, Louisiana versus Pittman Construction Co., Inc.,* Volume 264, *Federal Reporter, 2nd Series,* p. 695 (United States 5th Circuit Court of Appeals, 1959)

involved (48, citing *Goldberg v. Kelley,* (49)). In fashioning a scheme to afford due process to the disqualified bidder, the court identified the interests being balanced:

> "The interests to be balanced in cases involving Louisiana's public bid law are the interests of a particular bidder in receiving the contract versus the public interest in having the contract awarded expeditiously to the bidder who can most economically perform the work in a responsible manner." (47, p. 1166)

The procedure established by the court is codified in part in Section J of the Public Bid Law.

> "LSA-RS 38:2212(J). If the public entity letting the contract proposes to disqualify any bidder, such entity shall:
>
> (1) Give written notice of the proposed disqualification to such bidder and include in the written notice all reasons for the proposed disqualification; and
>
> (2) Give such bidder, who is proposed to be disqualified the opportunity to be heard at an informal hearing at which such bidder is afforded the opportunity to refute the reasons for the disqualificaton."

The procedure outlined by the court contains four steps. First, it requires the apparent low bidder be given written notice, before the award of the contract, that disqualification is being considered and the specific reasons for the proposed disqualification.

> "The notification should contain specific language which puts the bidder on notice that the authority is considering disqualification, not mere questions about the bidder's past performance on state contracts or its ability to perform in the future." (47, p. 1166)

Then the bidder must be given the opportunity to respond in writing and where feasible the opportunity to meet with officials of the awarding authority to discuss the charges. After this informal hearing and also before the award of the contract, the awarding authority must give the bidder formal written notice of disqualification and list the specific reasons for the disqualification. Finally, the "records" of this proceeding must be preserved to form the basis for any subsequent judicial review sought by the bidder (47, p. 1166). Judicial review appears to be of right, and does not require an independent showing of cause. "Courts will not substitute their judgment for the good faith judgment of an administrative agency. Nevertheless, an

awarding body's administrative discretion must be exercised in a fair and legal manner and not arbitrarily." (47, p. 1165)

In applying the *Haughton* procedure, some of the Circuit Courts of Appeal find a substantially unresponsive bid does not vest the bidder with a protected interest subject to due process protection (see *Systems Plus, Inc. v. East Jefferson General Hospital* (50) and *Triad Resources and Systems Holding, Inc. v. Parish of LaFourche* (51)). Such exception has not been addressed by the Louisiana Supreme Court.

Changes to Current Law Necessary to Permit LaDOTD to Adopt Innovative Contracting Techniques

Pre-qualification. Licensing requirements, bonding capacity, and certification of compliance with government regulations such as Equal Employment Opportunity and others, are permissible types of pre-qualification. The Louisiana Supreme Court has clearly held other forms of bidder pre-qualification to violate the Public Bid Law. Adoption of the Bidder Pre-qualification System presented in this report would, therefore, require direct amendment to the Public Bid Law or enactment of a statutory exception to the requirement for compliance with the Public Bid Law. However, the existing condition of the law would appear to permit the LaDOTD to utilize a system of this type in the post-bid evaluations of bids actually submitted. Because the Public Bid Law is deemed as a matter of constitutional law to create a protected interest in the apparent low bidder, any disqualification of such bidder would have to satisfy the requirements of procedural due process and would be subject to judicial review.

Whether the constitutional requirement of due process would protect the interests of prospective bidders eliminated from competition by a pre-bid qualification system could only be resolved by the courts after its implementation. If a protected interest were found to exist in the bidders excluded from competition by the system, the analysis would proceed to an examination of each individual element for constitutional soundness. As an example, the requirement for disclosure of the number of contracts involving litigation could be tested as an infringement of the access to courts clause in the Louisiana Constitution. Finally, the procedure whereby the system was applied and the adequacy of notice to and opportunity to respond by the potentially disqualified bidder prior to disqualification would be reviewed.

A + B (Lane Rental) Bidding. Selecting a contractor based upon submittal of the A + B Bid Form presents a modification to the selection procedure of the Public Bid Law. Using this contracting option, selection continues to be based upon the low bid and the bidder's qualifications, but the bid includes a fictitious number based upon days to completion and a lane rental multiplier supplied by LaDOTD. The contract then includes a provision for incentive-disincentive payments based upon the contractor's actual schedule performance as compared to the schedule.

Although "lowest responsible bidder" is not an expressly defined term in the Public Bid Law, it has been defined through the jurisprudence as indicated in the previous section. It would be the recommendation of this author to amend the statute to define the term and to make special provision for use of the A + B form of bid. However, to the extent the selection based upon this form of bid operates to deprive an apparent low bidder of the award of contract, the decision of the agency would be subject to judicial review at the request of the apparent low bidder.

Design/Build. If approached as a competitive bid, the design-build contracting option fails to satisfy the selection process provided for professional services consisting of engineering and architectural services. LSA-RS 38:2313. If approached as a pre-qualification review and negotiation for scope and services, the option fails to satisfy the Public Bid Law. LSA-RS 38:2212. It would be necessary to amend both statutes to provide exceptions for this contracting option. To the extent the option operates to disqualify an apparent low bid or to exclude an interested party from competing, it will be subject to constitutional challenge as described in regard to the pre-qualification of bidders.

RECOMMENDATIONS (SUB-PROJECT A)

The process of developing a software package to assist LaDOTD contract technicians develop accurate and consistent contract time estimates has entailed a detailed review of procedures currently used in LaDOTD as well as methodologies followed by other states. The following recommendations result from this review.

A Quantity-Production Rate (QPR) Approach Should be Retained

The arguments for basing contract time calculations on QPR techniques are strong.

- The list of work items is standardized and is used as the basis for the contractor partial payment schedule.
- The quantities for the listed work items are summarized in the project plans.
- The calculations required to estimate the contract time are simple; thus allowing the estimated time to be obtained quickly.
- The production rates upon which the work item durations are calculated can be quantitatively verified.

A Project Template Approach Should be Implemented

In studying the existing contract time determination procedures, it became obvious that knowledge of construction procedures and scheduling were necessary to adjust the contract time obtained by straightforward QPR calculations for work activity overlap. Contract technicians rarely have the field experience to make the judgements independently. Adopting a construction template approach allows these decisions to be made by experienced construction engineers. Their knowledge and experience are encapsulated in the templates, thus partially relieving the contract technicians of this responsibility and improving productivity. Selecting the proper construction template for a project is key to successful implementation of this concept and should be done under the direct supervision of the contracts engineer. Maintaining the template repertoire will require a review periodically by the contracts engineer in consultation with the Construction Division.

The CTDS Should be Used for Most Contract Time Determinations

The use of the CTDS package developed by this project will provide a well-documented and tested work environment for performing contract time calculations. Only when a project does not cleanly fit into one of the twenty-two templates provided should a manual determination be pursued. Technical information required to modify existing templates or add new templates to the program is provided in Volume III of this report.

Presently the CTDS is installed on only one computer in the Contracts Section. Because technicians must continually refer to project plans and other reference materials when developing a contract time, more convenient access to the computer needs to be provided. To provide maximum benefit, each technician should have a computer accessing the program through a network.

Production Rates Should be Monitored on a Continuing Basis

The greatest portion of time and effort for this research project was dedicated to determining verifiable production rates based on data obtained from recently completed construction projects. These productions are listed in Appendix D and have been incorporated in the CTDS program. A statistical analysis of the data used to develop the production rates is provided in Appendix E. Several recommendations are offered which will enhance the process of capturing such data in the future and improve the reliability of the data obtained.

Implement Automated Procedures for Collecting Production Rates

The quality of the daily diaries maintained by project engineers varied greatly over the range of projects reviewed for this study. This is especially true when reviewing the actual quantities of work item production included in the reports. This shortcoming led to the development of four different schemes for estimating production when quantitative information was not recorded. The adoption of an automated system for collecting work progress information, such as the AASHTO "Construction Management System", would provide a consistent vehicle for recording accurate reports of daily work progress. Data from an automated system would greatly simplify and improve the accuracy of production rates used in the CTDS software.

As an interim solution, project engineers and inspectors should be given specific instructions and training for filling in daily diaries in a consistent format, with emphasis being given to the need for quantitative data.

Adopt a Calendar Day Basis for Contract Time

The FHWA recommends against the use of the "work day" concept and in favor of a calendar day basis (4). The detailed review of the daily diaries for nearly 100 completed construction projects reveals that there is little consistency in the charging of work days by the project engineers. A summary of the analysis of work day charges for the projects reviewed is included in Appendix M. Many projects showed a substantial number of days where the contractor worked and achieved measurable results, yet work days were not charged. Adopting a calendar day basis for contract time would remove the single greatest variability in the calculation of production rates. Other benefits are likely to accrue.

Additional Production Rate Research

There have been numerous production rates generated from this research. However, there were no production rates computed for the "lump sum" items. This limitation is attributed to the inadequacies in the daily diaries for reporting the material quantities associated with these "lump sum" items.

Because many of the templates require production rates for the "lump sum" items, these templates will have to be closely monitored by the contracts engineer to eliminate improper contract times. The research team recommends that LaDOTD investigate the production rates for these items.

RECOMMENDATIONS (SUB-PROJECT B)

After careful study of current Louisiana construction contracting practices and innovative contracting techniques, the research team perceives the following needs:

- Improve the communication between LaDOTD personnel and construction contractors' personnel,
- Improve the process for avoiding and resolving disputes,
- Enhance construction quality,
- Minimize construction time on time sensitive projects,
- Improve the quality of construction plans and specifications, and
- Improve the system for determining qualified contractors.

Implement Automated Procedures for Tracking Projects

To evaluate these concepts, a historical data base of project characteristics is needed. LaDOTD should begin keeping detailed records of project characteristics, e.g., number of disputes, construction costs, number of plan changes, etc., so that innovative projects can be compared to traditional projects to determine the level of success. The adoption of an automated system for collecting work progress information, such as AASHTO's "Construction Management System," would provide a consistent vehicle for recording project characteristics.

Use Design/Build on an Experimental Basis

Although D/B has been used on an experimental basis in other state DOT's, it has never been approved on a permanent basis. Because D/B substantially changes the relationships, legal and otherwise, among designer, owner, and contractor, the research team recommends that statutory changes be made to allow the use of D/B concept on an experimental basis. A detailed evaluation of the advantages and disadvantages should be performed during the trial period before permanent statutory or constitutional change is considered.

For D/B contract documents, we recommend LaDOTD fashion any new documents after design/build contract documents now available from the ASCE. Because this practice is much different from current LaDOTD practices, a completely new set of documents will be needed. In addition to the general contract provisions, detailed project specifications, requirements, and responsibilities will need to be carefully written. In general, D/B is recommended only for use on the following types of projects: (52)

- when the project's scope is well-defined,
- when time is critical,
- when the owner is inexperienced in the type of work,
- when the contract team is experienced in the type of work,
- when project risk is low to medium, and
- when quality should be at industry standard or slightly higher.

Before D/B is used, several critical factors must be in place, including:

- statutory or constitutional changes that provide for use of D/B;
- the owner should have a series of contract documents that provides, and, in fact, encourages the individual players to behave as a team, minimizing conflict of interests;
- the owner has a well-defined method for prequalifying potential contractors
- the team is well-organized and cohesive.

Use Privatization on an Experimental Basis

The use of privatization in the United States by the public sector, including state DOT's, is growing. The research team does not heartily endorse privatization, but recommends its use on a carefully chosen project on an experimental basis. During

that trial period, the advantages and disadvantages for the LaDOTD should be carefully studied before considering permanent implementation.

Standard privatization contract documents are not generally available, since these documents are usually created on a project-by-project basis. Similar to D/B, these types of contracts radically change the relationships among designer, owner, and contractor from current construction contracts. In addition, use of these concepts may be illegal in Louisiana (1) because they eliminate the competitive low bid process required under public bid laws, and (2) because the experience of the design professional may not be the primary reason for selection of the designer, as required under the state's Brooks Law.

Another issue that must be resolved is financing. Typically, projects using privatization are funded by future users that stand to profit from the facility, including developers contributing capital, direct users paying tolls, and surrounding real estate districts paying taxes.

Several other issues should be included in the contract: clearly written performance standards, acceptable methods for measuring performance, acceptable penalties for nonperformance, simple dispute resolution procedures.

Before the LaDOTD can use privatization, careful attention should be given to several details:

- services currently offered by LaDOTD, to ensure that only required services are being offered;
- costs associated with services offered by LaDOTD, to ensure the costs are competitive with those of equivalent services available through private enterprise;
- legislation related to privatization, to empower LaDOTD to use privatization contracts; and
- system to prequalify potential contractors, to ensure that only the best private sector companies are eligible to provide these services.

We recommend that these concepts be used in the following circumstances:

- where the private sector can make a profit;
- where the private sector can offer the services cheaper than LaDOTD;
- where the contractors have the required experience;
- where the public will not sacrifice quality of service or product;
- where the public agency can properly supervise the contractor.

Take Steps Toward Implementation of Contractor Prequalification

Although currently unconstitutional under Louisiana's constitution, the potential benefits for using prequalification is significant enough for LaDOTD to begin taking the steps needed to allow its use on an experimental basis. The following detailed recommendations relate to steps needed to begin contractor prequalification in Louisiana.

Change Current Law

As previously discussed above under "Some Statutory Considerations" (p. 80), current Louisiana law would need to be changed to allow this concept, even on an experimental basis. The research team recommends that appropriate steps be taken to revise the law.

Create a Contractor Prequalification Analysis Scheme

We recommend that LaDOTD implement a prequalification analysis scheme discussed earlier (p. 57), and as laid out in Appendices H and I. The following recommendations summarize the research team's findings:

- The prequalification system should be administrated by one engineer with considerable construction and managerial experience in bridge and highway construction.
- A prequalification committee, consisting of three experienced LaDOTD construction engineers, should be created to resolve borderline

contractors and disagreements between contractors and the prequalification engineer.

- Prequalification is not recommended in the following situations:
    - where only a few contractors are qualified for the project because of the capital, equipment, or experience requirements;
    - where use of the system will eliminate competition among contractors;
    - where the project requires new technology that only one contractor is familiar with; and
    - projects with an estimated contract value of less than $50,000.
- Create a "Contractor's Evaluation Report," to be completed by the project construction engineers, to evaluate contractor's performance on project. Link this report into the prequalification system.

- Subcontractors will not be prequalified under the proposed system, but may be approved by the LaDOTD construction engineer. The object is to give new contractors a chance to gain experience under the supervision of a prime contractor.

- Validation of the proposed prequalification scheme was beyond the scope of this research. LaDOTD should test and validate the system for a period of time, and to modify it accordingly, prior to full implementation.

Recommended Bidding Procedures Using Prequalification

Prequalification of contractors can be conducted on an annual basis for typical projects, and on a project-by-project basis for complex and non-typical projects. Most highway and bridge construction work could be categorized as typical work. Examples of non-typical bridge and highway construction projects include: suspended bridges, very long bridges, tunnels, new long interstate highways, and any project with an estimated cost of greater than $40 million. In addition; typical projects with contracting procedures other than design-bid-construct are also non-typical projects.

Projects with an estimated contract value less than $50,000 would not require prequalification. Projects with an estimated value of less than $50,000 usually are

not complicated and do not require high qualifications. We do recommend the use of a licensed contractor on these type of projects

For typical projects, prequalification should be conducted at least once every year at a fixed time, or if new events occur between annual prequalification then the prequalification analysis should be conducted again on a case-by-case basis. Examples of these events are the following:

- purchasing, leasing, or selling of equipment;
- hiring or terminating a key employee with technical and/or managerial expertise;
- restructuring the company;
- failing to complete a project;
- trouble on a project with the LaDOTD.

Prequalification Procedures for Typical Projects. For employing prequalification for the first time on LaDOTD projects, the owner should send an invitation to contractors and the press announcing the introduction of a new prequalification system. The announcement should state that, on all future projects, award will be made only to prequalified bidders. The letter and the announcement should inform the interested contractors how, when, and where to obtain the prequalification application from the owner, and when and where to return it.

The prequalification package should include, among other things, the prequalification application form presented in Appendix H; the prequalification analysis scheme presented in Appendix I; and the prequalification instructions. The prequalification instructions include, but are not limited to, the following information:

- name, address, and voice and facsimile telephone numbers of the contact person;
- deadline date for returning the completed application;

- application filing instructions; and
- evaluation period.

Following completion of the prequalification application, the contractor sends it to the owner who evaluates and analyzes the information from the application form and other sources. The owner makes a decision about who is qualified and who is not qualified using the prequalification analysis scheme. Then, the owner notifies the contractors, explaining the prequalification decision to the contractors.

One of the best potential sources of information about the performance of the contractor would be a "Contractor Evaluation Report." Such a document is recommended for use by LaDOTD construction engineers to rate a contractor's project performance. The prequalification system should be linked with the evaluation.

When the owner needs to employ a contractor to construct a project, the owner checks his list of prequalified contractors for this type of projects. Then the owner sends the prequalified contractors the bid invitation with a brief description of the project, requesting bid proposals from interested contractors. The LaDOTD could also announce the invitation to bid in relevant publications.

When the interested and prequalified contractors request the bid documents, the owner sends it to them. Disqualified contractors, who believe that they are currently qualified for the job should complete a prequalification application. If they became qualified, they get a copy of the bid documents to prepare a bid. If there is not enough time to conduct prequalification, then prepare and submit a bid, the contractors may apply for prequalification and prepare the bid at the same time. The time and money spent in preparing the bid are the responsibility of the contractor, and the owner has no obligations to accept bids from disqualified contractors. The prequalified contractors study the bid document, estimate the cost, and prepare and submit their bid packages.

After the bids are received, the owner checks and analyzes them. Then LaDOTD conducts post-qualification of the lowest bidder, including checking the bidder's current bidding capacity. During post-qualification, the owner checks the accuracy and correctness of the provided information in the prequalification application by

contacting all the previously mentioned sources of information. The owner awards the contract based on the bid.

Prequalification Procedures for Non-typical projects. The bidding procedures for non-typical projects using prequalification could be summarized in the following steps:

- The owner determines the objectives of the project and alternative means to achieve those objectives;
- The owner determines the particular requirements of the project and the needed strengths for the constructors to meet those requirements;
- The owner designs a prequalification application and a prequalification analysis scheme based on the above mentioned objectives, requirements, and strengths;
- The owner announces an invitation or a request for prequalification in the proper press; the announcement should contain all the information mentioned in the bid invitation for the typical projects but on a briefer form;
- The contractors request a prequalification application and complete the application and return it to the owner;
- The owner evaluates the completed prequalification applications, using the previously reported prequalification analysis scheme, and determines who are the prequalified contractors then sends the bid documents to them;
- At the same time, the owner writes to the disqualified contractors explaining the reasons for disqualification.
- The prequalified contractors study the bid documents, visit the site, ask questions, collect information, estimate the direct and indirect costs, prepare a bid proposal package, and submit it to the owner before the deadline;

- The owner evaluates and analyzes the bids, and conducts post-qualification for the lowest bidder; then

- The owner awards the contract based on the above mentioned analysis.

Use Time Incentives/Disincentives on Experimental Basis

Sample Experimental Plan

On construction projects where time is of the essence, we recommend the LaDOTD experimentally evaluate the use of Cost Plus Time (A + B) bidding (with a time I/D's), and Lane Rental. Before setting any permanent policy for using Time I/D's, we recommend that LaDOTD conduct an experimental review of these procedures on at least 10 projects.

Each project should be evaluated in the following areas: (53)

1. Compare actual construction duration with the construction time estimated by a professional LaDOTD engineer prior to bidding.

2. Compare the number of projects awarded to bidders that bid the least number of calendar days with the number of projects awarded to bidders that did not bid the least number of days.

3. Determine the number of projects where the bid days was exceeded.

4. Compare the number of claims involving work subject to the Time I/D with the number of claims involving other non-Time I/D work.

5. Compare the quality of work on Time I/D versus non-Time I/D projects

6. Compare cost of construction on Time I/D versus non-Time I/D projects.

Other evaluation criteria could be added as appropriate.

Project Selection Criteria

Because Time I/D bidding is intended to shorten construction time, it should be used primarily on projects where time is critical because of major inconvenience or delay to the highway user. In other words, these methods should be primarily used

on projects where early completion will provide substantial benefit to the facility's users.

On the other hand, it should not be used where project conditions are unknown, or where significant changes are expected. Changes in Time I/D projects can defeat the purpose of the incentives, and can create disputes about how much time should be included in the change.

Typical guidelines for selecting projects for Time I/D bidding, include ("Implementation Guidelines for A+B Bidding," State of New York, Department of Transportation, Office of Engineering):

1. Projects that disrupt traffic enough to produce a daily users' cost of $3,000/day or greater;

2. Projects to reopen bridges out-of-service to traffic resulting in saved users' cost greater than $3,000/day;

3. Projects that require long off-site detours, increasing the travel time by 7 minutes or more;

4. Projects that are of special concern because of interference with public events, or because of public interest.

5. Work that will complete a gap in the highway system resulting in saved users' cost greater than $3,000/day.

Another consideration is when to use A+B versus lane rental. Use lane rental when:

- the lane closure increments will be measured in fractions of a day, e.g., hour, half-hour or quarter-hour;

- the traffic volume is very high;

- the congestion caused by construction will be very high; and

- where traffic restrictions must be kept to an absolute minimum.

Use A+B when:

- the lane closure increments will be measured in days (or longer),
- the traffic volume is moderate to high,
- the congestion caused by construction will be moderate to high, and
- where total construction time is more important than lane closure time.

Calculation of Users' Cost

Calculation of users' cost will depend a great deal on how LaDOTD prefers to calculate time delays. If LaDOTD currently has a traffic model that will generate these values, then LaDOTD could simply use a form of the equations given in the "Results" section. If LaDOTD does not currently use such a model, then use of HEEM-III or QUEWZ, or some other model, should be explored.

Documentation to be Included in the Proposal and Contract Documents

The following documentation, in some form or another, should be included into the Proposal and Contract Documents. Sample documents are contained in Appendix K:

1. A revised Notice to Contractors alerting them that the I/D Bidding Method applies to the contract.
2. A Revised Proposal Form to allow contractors to bid the time portion of the bid.
3. A completed Special Provisions for the I/D Bidding Method.

Institute Quality Incentives/Disincentives Based on Life-Cycle Cost Analysis

For quality incentives/disincentives to be useful, LaDOTD would need to move toward the use of performance-related specifications (PRS) to give the contractor the flexibility needed to fully implement this concept. Since LaDOTD is currently moving away from PRS, it will be difficult to implement Quality I/D's.

Although LaDOTD has, for the most part, abandoned what they call "performance-related specifications," some performance-related language remains in the standard specifications, e.g., in the *Louisiana Standard Specifications for Roads and Bridges, 1992*, Table 1, "Payment Adjustment Schedule" for rigid pavement (p. 200). Some argue that because LaDOTD standard specifications include deductions for providing lesser quality than specified, as found in said Table 1, those deductions are "disincentives" or "penalties" on the contractor. Others further argue that to properly motivate the contractor, "incentives" should also be given to allow the contractor to earn additional compensation for higher quality.

In general, we do not agree with the idea that deductions in pay for below standard quality are "disincentives" or "penalties." These deductions would be penalties only when the deductions are greater than the "lost value," which is the difference between the value of the desired quality product and the value of the provided quality product (if lower). Therefore, when the LaDOTD uses deductions, we recommend those deductions be set equal to the "lost value," based on careful, accurate, and justifiable life-cycle calculations.

Further, we do not agree with the idea that quality deductions should be complemented with quality incentives. In fact, it may be illegal, under the public bid law, to allow these quality deductions without proper engineering consideration, since the contractor would be providing a product not specified in the initial bid documents. It would be legal, however, when the professional engineer (not the contractor) on each project designs the alternatives into the project, possibly due to a value engineering review. (If implemented properly, value engineering should identify areas of design needing these types of alternatives.) Alternative designs already occur in LaDOTD projects. In said Table 1, the contractor is given several alternatives for constructing the pavement. It is assumed that the engineer has evaluated each design alternative, and established the value for deduction based on engineering materials and economics principles.

We recommend that engineers at LaDOTD begin asking, "Why do we allow these construction alternatives (such as in said Table 1) on our projects?" and "Are these alternatives and their corresponding deductions based on engineering economics?" Based on feedback from LaDOTD personnel, we believe that contractors provide a product that maximizes their profits, not the construction quality. Therefore, we recommend that LaDOTD establish standard specifications based on state-of-the-

art engineering practices for analyzing material properties and life-cycle costs. It is only through life-cycle cost analysis that the equity and value of alternatives can be determined. It is the engineer's responsibility to consider the economics of different designs, and specify the design that provides the lowest life-cycle cost to the public.

Use Dispute Review Board (DRB) on Experimental Basis

It is our recommendation that the LaDOTD experiment with using DRB'S on several projects that include partnering. There are several possible configurations of a DRB. Appendix L gives a specification of a DRB composed of just one individual. Another possible configuration is for the dispute review board to be composed of three (3) individuals. The board could be created so that all three individuals are from companies external to both the LaDOTD and the contractor; both parties should agree on these individuals before the project begins. Or the board could be created so that one individual is from the LaDOTD, one from the contractor, and one from an external company, mutually agreeable to both parties. These individuals should be knowledgeable in the construction and design areas, and should remain neutral at all times. Ideally, the board members should visit the job site once a month, allowing the board members to become familiar with all aspects of the project, including all areas of conflict and any possible source of disputes. Under these recommendations, the dispute review board members would be involved with the project from the beginning, but they would not actually resolve disputes until the contractor and LaDOTD rejected each others' decisions.

Use Cash Allowances on Projects with Major Equipment

The survey results do not reveal cash allowances as a popular concept among state DOT's. The apparent benefits, i.e., better control of major equipment suppliers, are generally not applicable in road construction. Use of this concept should be considered, however, in projects encompassing major equipment (i.e., pump stations, docks, etc.).

Expand the Use of Guarantee/Warranty

In order for guarantee/warranty to be more effective, the LaDOTD current specifications would need to be altered to give the contractor more control of construction materials and techniques. In other words, LaDOTD would need to move away from their current specifications and more toward PRS, thereby giving the contractor more freedom for choosing how the project is constructed. Then LaDOTD could hold the contractor responsible for the final product. As it is now, the

Department accepts most of the responsibility for the final product. Because LaDOTD has decided to move away from PRS, use of guarantee/warranty will only work in certain circumstances, such as in equipment specifications. We recommend expanding the use of the guarantee/warranty concept when appropriate.

Expand the Use of Partnering

The State of Louisiana currently has a provision for implementing partnering on all projects larger than five (5) million dollars. Since partnering has proven advantageous in Louisiana as well as in other states, we recommend that partnering efforts be continued. The LaDOTD should experiment with partnering on projects of smaller cost to determine if the concept produces beneficial results.

Expand the Use of Value Engineering

Value engineering is another concept that should be considered for use on many more LaDOTD construction projects. A value engineering team of four (4) to six (6) individuals with diverse backgrounds should be developed. We recommend the team be composed of construction, maintenance, operation, and design personnel, one of which would serve as the value engineering coordinator. Members of the team should be persons with creative and inquisitive minds who are able to work cooperatively with others. Note that the value engineering team members must be relieved of all other responsibilities and assignments while performing team assignments so that their full attention can be placed on the project. The value engineering team should evaluate the plans and specifications for constructibility, practicality, safety, and cost effectiveness. This review should occur in the design phase before advertisement for bid.

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