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16. Abstract

The use of consultants in providing pre-construction engineering design services for the state's Departments of Transportation has increased over the last twenty years. This has resulted in several investigations into the cost-effectiveness of this trend. This paper reviews past studies, examines their methodology, suggests improvements to certain parts of the commonly-used investigative process, and demonstrates their use in an application to the Louisiana Department of Transportation and Development.

The suggested improvements to methodology are described and used in this study. They include using the same project to compare in-house and consultant design costs (rather than the use of similar projects, as in most studies), performing a detailed analysis of overhead rates that are comparable between the State agency and consultants, and measuring comparative design costs as the ratio of in-house to consultant design costs (rather than the ratio of design to construction costs commonly used in past studies).

Most studies in the past have concluded that consultant design costs are higher than in-house design costs or that there is no significant difference in cost. The Louisiana study found that consultants are approximately twenty percent more expensive than in-house staff in preparing road and bridge designs but that the difference was almost entirely due to the extra cost of contract preparation and in-house supervision required for consultant designs.

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LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

IN-HOUSE VERSUS CONSULTANT DESIGN COST STUDY

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ABSTRACT

The use of consultants in providing pre-construction engineering design services for the state's Departments of Transportation has increased over the last twenty years. This has resulted in several investigations into the cost-effectiveness of this trend. This paper reviews past studies, examines their methodology, suggests improvements to certain parts of the commonly-used investigative process, and demonstrates their use in an application to the Louisiana Department of Transportation and Development.

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IMPLEMENTATION STATEMENT

The information from this study documents the final report presented to the Project Review Committee assigned by DOTD for this project. The information will be used by the DOTD and the State Legislature in formulating policy on appropriate workforce policies for the Department in the future.

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EXECUTIVE SUMMARY

Problem Statement

The Louisiana Department of Transportation and Development (DOTD) currently uses both consultants and in-house staff in designing transportation facilities for the department. However, the relative cost of this practice is not known. Is it cheaper or more expensive to use consultants rather than in-house staff in delivering these services? Knowing this would assist the state in establishing policies that promote efficient public service.

Objectives

The objectives of this study are to:

1) Identify and compare the cost of providing pre-construction engineering services to DOTD when these services are provided by in-house staff or, alternatively, by consultants and,

2) List the other factors that are relevant to establishing an optimum balance between the use of in-house staff and consultants in providing pre-construction engineering services to the department.

Literature Review

With one exception, 16 other similar studies have found pre-construction engineering design work by consultants to be more expensive than in-house design work. The most difficult aspect of the comparisons is establishing equitable, accurate overhead rates. These were found to range from approximately 50 percent to over 300 percent, illustrating the diversity, interpretation, and level of detail employed in past studies.

Review of Earlier DOTD Investigations

DOTD has conducted internal investigations to estimate in-house versus consultant cost of pre-construction engineering services, the last in 1996. The earlier studies were reviewed to determine their data, methodologies, and findings.

The method employed by the department in the most recent investigation involved pairing each actual cost of design with an estimated consultant cost using design-cost estimation formulae. Thus, actual in-house design costs were compared to "what would have been paid to consultants had the work been outsourced." Similarly, actual consultant design work was recast using in-house cost rates. This approach allowed comparison among the same projects, as well as the opportunity to compare labor hours and labor rates between in-house and consultant staffs. Clearly, the validity of the approach depends on the accuracy of the formulae and the integrity of their application.

In applying the simulation approach to three projects - two in-house and one consultant - the 1996 departmental study found in-house design work costs less than consultant work.

The above methodology was adopted as the basis of investigation for this study. However, the sample of projects was increased considerably, and a detailed investigation of overhead rates was conducted.

Review of DOTD Organizational Structure

The organizational structure within DOTD was reviewed to determine the direct and indirect involvement of its functional units in pre-construction engineering. This review determined that the following eight sections were most directly involved in the design process:

18—Consultant Contract Services,
20—Engineering and Program and Project Development,
24—Road Design,
25—Bridge Design,
27—Geometrics,
29—Hydraulics, and
67—Soils

Review of DOTD Data Sources

A review and evaluation were made of the DOTD data sources that can be used to quantify the cost of providing pre-construction engineering services. Accounting data from a variety of sources were used extensively in identifying in-house labor costs, conducting reasonableness tests of the payroll system, and identifying the internal overhead rate.

The department has several information systems that are not integrated, making it difficult to determine total costs of individual projects. Although generally reliable, the data are not readily available for decision-making as the following instances illustrate:

1) Engineering consultant costs are not available on any computer systems and are available in a manually administered accounting ledger only.

2) Because of annual closings of accounting data, queries must be submitted to the computer center for multi-year projects, taking several weeks to obtain information.

3) Several different project number coding systems are used, but there is no adequate cross-referencing system.

4) There are no function codes used for consultant work such as preliminary design, final design, survey, etc.

Gangs (i.e., work teams) experimenting with an online payroll system had more accurate and higher project charge rates than most other gangs using the manual timesheet method.

Analysis of Overhead

The average consultant overhead rate for 37 consultants audited in 1995-96 was 158 percent, increasing to 192 percent when profit (13 percent of total cost) is added.

Furthermore, departmental contract initiation and supervision of consultants add another 15 percent and 25 percent to total costs for road and bridge design, respectively. This results in final effective consultant overhead rates of 236 percent for road projects and 265 percent for bridge projects.

Comparison of Overhead Rates, 1995-96

Section	Overhead Rate
Section 24 (Road Design)	186%
Section 25 (Bridge Design)	212%
Average Consultant Overhead Rate	158%
Effective Consultant Overhead Rate:	
Road Projects	246%
Bridge Projects	276%

In-house overhead rates were established by adding the pro-rated cost of support services and upper management supervision to individual section overhead costs. The resulting overhead rates were 186 percent and 212 percent for Section 24 (Road Design) and Section 25 (Bridge Design), respectively.

Self-insurance assigned to the department by the Office of Risk Management was a substantial portion (61 percent) of the total indirect support services cost. However, 63 percent of this cost was related to an umbrella general liability not associated with the insurance provided in consultant insurance plans. Subsequently, the unassociated cost was excluded in determining departmental overhead rates, resulting in an insurance cost of 6.7 percent of total costs for in-house projects. For consultant projects, analysis of the audited information showed it to be 5 percent of total costs.

The time charged to projects for the road and bridge sections as a percentage of total working hours (including leave) was 52 percent and 48 percent, respectively, for 1995-1996. The average charged time for 104 consulting firms audited by DOTD during 1993-96 was 63 percent (range: 41-87 percent).

Departmental average salary rates were 9 percent to 33 percent less than consultant rates at all six skill positions included in the study. However, because departmental fringe benefit rates (58 percent) exceeded consultant fringe benefit rates (33 percent), little difference existed between salary rates when fringe benefits were added.

Results of Analysis of Costs of Projects

For analysis, the study team selected a sample of 20 in-house and 17 consultant designs to represent the cross-section of projects typically considered for outsourcing to consultants, including various project types such as river crossings, railroad overpasses, two-lane rural roads, intersections, and four-lane rural roads. All projects were let or completed within the last five years.

Departmental engineers used the formula to simulate consultant costs for the 20 in-house designs "as if the design work had been given to a consultant." Information from the 17 consultant designs was used to simulate in-house costs “as if the same number of labor hours were used in-house as allowed the consultants in the formula.” The first approach includes differences in work effort since the actual number of labor hours were used for the in-house projects while consultant hours were estimated. The second approach isolates differences in salary and overhead rates since the number of hours is constant. A third approach involved identifying the average cost of one design hour of in-house and consultant design staff. The average mix of design staff was used to make the comparison.

Using the first approach, the analysis of in-house designs revealed that:

1) In-house costs were much less than for consultants. Average in-house costs were 65 percent and 76 percent of simulated consultant costs for road and bridge design, respectively. The simulated consultant costs were higher for all designs.

2) Comparison of the average direct labor hours spent on projects did not indicate any significant difference between in-house labor hours and consultant labor hours. However, smaller projects tend to be done in-house with fewer number of hours, while larger projects tend to be done by consultants with fewer number of hours.

Using the second approach, analysis of the consultant designs revealed that simulated in-house costs averaged 83 percent and 81 percent of consultant costs in bridge and road design, respectively.

In the third approach, 35 actual consultant design projects were used to calculate the mix of staff positions typically used in a consultant design project. Consulting salary, overhead rates, profit and DOTD supervision costs were applied to this mix of staff to compute an average cost per design project hour for consultants. Similarly, the total recorded cost of 20 in-house projects was divided by the total number of design hours to establish an average cost per in-house design hour. In-house overhead rates were applied to this cost. Based on this approach, in-house design costs averaged 77 percent of consultant costs for both road and bridge design.

Other Factors

A 1984 study (Cook, 1985) found that the majority of states did not consider cost as a major factor in deciding on the level of consultant use. One reason was that cost comparisons are not sufficiently accurate. From reviews of several reports and following discussions with persons familiar with the topic, the following factors, other than cost, are suggested as being relevant in establishing an appropriate level of consultant use:

1) The ability to accommodate fluctuating demands by using consultants to handle peak demand.

2) The ability to meet deadlines by using consultants when in-house resources are insufficient for the amount of work that must be completed in a specific period.

3) Access to specialized expertise which state DOT's cannot afford to maintain on a permanent basis.

4) Use of consultants as an extension of the DOT's workforce without the need to appoint, train, accommodate, and manage additional in-house staff.

5) Support of the consulting industry to help make it an economic and professional resource for the state.

6) Maintenance of experience among consultants of the department's procedures and standards to allow delivery of high quality consultant design work requiring the minimum departmental supervision.

7) Establishment and maintenance of a working environment that allows meaningful training, experience, and career development for in-house staff to retain the level of knowledge and experience necessary to supervise consultant work effectively.

Findings

1) The cost of providing road and bridge designs to DOTD is, on the average, lower when provided by in-house staff than by consultants. The best estimate of the average cost for in-house designs is that it is 81 percent the cost of consultant designs for road projects and 83 percent the cost of consultant designs for bridge projects. It can also be stated with 95 percent confidence that the average cost of in-house designs are <u>less</u> than 88 percent the cost of consultant designs for road projects and <u>less</u> than 96 percent the cost of consultant designs for bridge projects.

2) The overhead rates of DOTD are 186 percent and 212 percent for Sections 24 (Road Design) and 25 (Bridge Design), respectively, whereas consultant overhead rates average 158 percent. However, adding profit makes consultant overhead rates increase to 192 percent, close to DOTD overhead rates, and adding the cost of DOTD consultant contract initiation and supervision makes consultant overhead rates higher than DOTD overhead rates, 236 percent and 265 percent, for road and bridge design, respectively.

3) The difference in design costs between in-house staff and consultants is primarily due to the cost of consultant contract initiation and supervision.

4) The cost for supervising consultant bridge designs is higher than for supervising consultant road designs, the average being 19 percent for bridge design and 10 percent for road design, while contract initiation is on the average 5 percent and 6 percent of contract cost for road and bridge design, respectively.

5) Supervision time on some consultant projects is 10-40 times greater than the most common supervision times.

6) Direct labor chargeable to design by design-related DOTD staff averages 48 percent of total working hours, including leave, compared to an average of 63 percent for consultants.

7) Man-hours for projects were not significantly different between in-house and consultant designs. However, it appears that small projects tend to require fewer man-hours when done in-house while large projects tend to require fewer man-hours when done by consultants.

8) Salary rates with fringe benefits are very similar among DOTD design staff and consultants.

9) The estimation formula for road designs has not been updated for several years and may not be accurate.

10) Recording of time spent on in-house design is inadequate.

11) Data on projects are stored in a variety of databases without full cross-referencing.

12) Consultant cost data are stored only in handwritten records, are difficult to retrieve, and are vulnerable to loss.

13) It is difficult, time-consuming, and sometimes impossible to extract cost information on projects.

14) The project numbering system is inadequate for project cost control.

15) The factors other than design cost that are relevant to establishing an optimum balance between in-house and consultant design work include the need to accommodate fluctuating design demand, being able to meet deadlines, having access to specialized expertise, having flexibility in workforce size, supporting the state's consulting industry, maintaining a core of consultants who are experienced in departmental requirements and standards, maintaining in-house capability to effectively supervise consultants, and maintaining an environment in the department which adequately serves the training and career development needs of in-house staff.

Recommendations

1) DOTD should consider all relevant factors when deciding an optimum balance between in-house and consultant design work.

2) The work assigned to consultants should be given to experienced consultants to minimize departmental supervision.

3) The formulae to estimate design costs should be updated regularly.

4) An attempt should be made to increase the proportions of time charged to design by in-house design staff to more closely match that of consultants.

5) The recording of time spent on in-house designs needs to be improved.

6) The project numbering system needs to be improved for effective project cost control.

7) The present information system needs to be upgraded to an integrated client-server system capable of providing timely, accessible, and useful information to engineers and managers for both in-house and consultant projects.

8) A total quality management program should be implemented to determine sources of variation in cost and quality of both in-house and consultant designs.

Areas of Further Study

The DOTD information system is not capable of providing useful and timely cost information for internal as well as external users. Further studies need to be done to analyze informational needs and establish an information system which serves the needs of the department.

The industry trend is toward a client-server environment which satisfies operational, financial, and managerial principles simultaneously, uses a common database; provides point-of-data entry, features consistency for users across applications, allows on-line, interactive editing and updating, eliminates redundant data, and ensures data integrity.

Off-the-shelve software such as SAP (Systems Applications and Products in Data Processing) is available and could provide such an integrated approach to information systems. The responsibility for data integrity should be with the staff using the data, not with the computing center.

Further studies need to be done to improve cost control of engineering design projects and to determine the variations observed in design costs.

INTRODUCTION

State transportation agencies commonly use consultant firms for some of their highway and bridge design. For example, the Louisiana Department of Transportation and Development (hereafter referred to as the "department" or "DOTD") currently uses both consultants and in-house staff in designing state transportation facilities. However, the relative cost of doing so is unknown. Is it less or more expensive to use consultants rather than in-house staff to provide these services? The answer to this question is the prime objective of this study.

Past studies in other states strongly suggest that consultants are more expensive than in-house staff in providing the design services needed by the department (Wilmot, 1995). These studies also reveal that it is difficult to make an accurate comparison of individual cost items within the public and private sector with complete equity. This is particularly true for indirect costs. The public sector, for example, has cost items such as the advertising of contracts, consultant supervision, and general administration not incurred by the private sector. Similarly, the private sector has costs not borne by public sector agencies, including taxation, marketing, and compliance with public sector organization procedures and standards. Moreover, costs incurred for office rental, utilities, senior administrative staff, and insurance are usually not incurred uniformly across private and public organizations.

OBJECTIVES

The objectives of this study are to:

1) Identify and compare the cost of providing engineering design services to DOTD when these services are provided by in-house staff or by consultants, and,

2) List other factors that are relevant to establishing an optimum balance between the use of in-house staff and consultants in providing engineering design services to the department. It is not the objective of the study to quantify the impact of these factors but only to list them.

The specific aim of this research is to be able to establish an estimate of the relative cost of providing design services to DOTD using consultants or in-house staff. Since it is the relative cost to the DOTD that is of concern in this study, the costs considered will be those expended by the Department irrespective of whether in-house staff or consultants are conducting the design.

The investigation must be made by an independent organization that has credibility and is capable of providing an assessment of conditions that are seen to be objective and impartial. The Louisiana Transportation and Research Center (LTRC) was commissioned to conduct the study, which it did by appointing a team from Louisiana State University to conduct the investigation.

The report is organized as follows: First, the findings from a literature review are reported. Second, the organizational structure of the DOTD and the units involved in road and bridge design are determined. Third, the general methodology used in this study is described. Fourth, computation of the DOTD and consultant overhead costs are reported. Fifth, the results from an analysis of design costs from a sample of projects is reported. Sixth, other factors affecting the decision to perform design work in-house or contract it out to consultants, are listed. The report is concluded with a summary of the findings of the study, recommendations; and areas for further study.

SCOPE

The scope of this study was restricted to design engineering costs on bridge and highways done in-house by DOTD or contracted out to consultants by DOTD. Costs of engineering design projects were restricted to those costs incurred by DOTD. Hence, the costs of engineering design contracted out are the fees paid to consultants plus supervision and contracting costs incurred by DOTD. The study did not investigate the costs incurred by the consulting engineering firms to perform the work. Moreover, costs of other State agencies (e.g., costs of the Department of Administration to review annual budget requests) were not considered to be within the scope of this study unless those costs were billed to DOTD (e.g., risk management insurance & annual audits). Finally the time period of study was restricted to fiscal operating years ended 1992 through 1997 for two reasons: (1) records were generally more reliable for this time period than years prior and (2) it was felt that this more recent time period had greater relevancy for future planning by DOTD.

LITERATURE REVIEW

Introduction

This review of existing literature serves two purposes. First, it shows the methodologies used by other researchers to compare costs in similar settings. Second, conclusions drawn by other researchers provide an indication of how costs of in-house engineering design tend to compare to those of consulting engineering design. Existing literature on this topic was identified from the literature listed in studies recently conducted by the department and Louisiana Transportation Research Center (LTRC), from searches using conventional literature search procedures, and from communication with DOTD and other officials familiar with the topic.

Recent work conducted by DOTD is summarized in a communication from the Secretary to Mr. Boland, General Counsel in the Louisiana Department of the Civil Service (DOTD, 1996) and references to recently conducted studies in other states are included in LTRC's Technical Assistance Report Number 3 (Wilmot, 1995). Presented below are highlights from three major studies that were similar in scope to this project. Brief descriptions of other, less comprehensive studies are also presented, and general conclusions of the studies are discussed.

It is important to remember that conclusions reached by other studies about a state's cost structure are not necessarily germane to other states. Therefore, the conclusions of the studies listed below may not hold for the Louisiana DOTD.

Review of Similar, Major Studies

Whether costs of in-house engineering work are lower than consulting engineering work is not a new question. Several state transportation agencies have commissioned studies to address this issue. The studies listed below were performed by independent consultants (University of California, Berkeley, Ernst and Whinney, Center for Transportation Research at the University of Texas at Austin, Texas Transportation Institute at Texas A & M), by government agencies (Missouri Highway and Transportation Department, Wisconsin Legislative Audit Bureau), and by professional engineering groups (Professional Services Management Journal Study).

The University of California, Berkeley study. The objective of this study was to compare the cost to the California Department of Transportation (CALTRANS) of employing in-house versus consulting engineering services staff in conducting designs for the department (Ashley et al., 1992). The study collected actual costs incurred by CALTRANS to complete the designs for a set of projects done in-house and a set of projects done by consultants. The ratio of engineering design costs to completed construction costs was used as a measure of relative design cost in each case.

The determination of the indirect costs incurred by CALTRANS under each alternative (i.e., in-house and consulting engineering) was a major part of the study. Since the method used by CALTRANS to compute an overhead rate was different from those commonly used in private industry, their indirect costs were adjusted to make them comparable with those of private consulting firms. The average ratio of design cost to construction cost for the two sets of projects were calculated and a statistical test was performed to determine whether there was a significant difference between the two. The study concluded that no statistically significant difference existed between the cost of performing engineering designs in-house or by consultant.

The Berkeley study is remarkable for its detailed analysis and discussion of overhead rates. In the study, overhead rates are expressed in two ways:

Approach 1:

$$\text{Overhead rate} = \frac{\text{Total Indirect Costs} + \text{Costs of Benefits on Direct Labor}}{\text{Direct Labor Costs Excluding Costs of Benefits}}$$

Approach 2:

$$\text{Overhead rate} = \frac{\text{Total Indirect Costs Not Including Costs of Benefits on Direct Labor}}{\text{Direct Labor Costs Including Costs of Benefits}}$$

CALTRANS used approach 2. Approach 1 establishes an overhead rate that is comparable to the formulation used in private industry. The Berkeley study preferred an overhead rate calculated using methods similar to private industry. Hence, the benefits were removed from the denominator and added to the numerator as suggested in approach 1. The following example reveals how the CALTRANS "original" overhead was converted to an industry-like rate using 1990-91 cost data from the Project Development Division in the department (see page 36 of the Berkeley study):

Approach 2: CALTRANS "Original" Overhead Rate

"Original" overhead rate =

$$\frac{\text{Total Indirect Costs}}{\text{Fully Burdened Direct Labor Costs}} = \frac{\$108{,}205{,}861}{\$165{,}996{,}794} = 65.2\%$$

Approach 1: Revised Overhead Rate Similar to Private Industry Overhead Rate

Revised overhead rate =

$$\frac{\text{Total Indirect Costs}}{\text{Fully Burdened Direct Labor Costs}} = \frac{\$108{,}205{,}861}{\$165{,}996{,}794} = 65.2\%$$

Three overhead rates were estimated for the Project Development and Construction divisions in CALTRANS. For the Project Development Division, the Berkeley study used the following three overhead rates: (1) the revised CALTRANS rate of 144 percent (page 36), (2) an adjusted rate of 155 percent that excludes project oversight costs (page 62), and (3) a fully adjusted rate of 175 percent (page 67). For comparison, the study cites private industry overhead rates from a PSMJ survey of consulting engineers in the transportation industry (page 86):

Percentile:	10th	25th	50th	75th	90th
PSMJ Survey OH Rate:	99%	123%	132%	156%	164%
CALTRANS OH Rate Range:					
Project Development:		144% to 175%			
Construction Engineering:		134% to 146%			

The study also provides a detailed list of cost items included in determining both indirect (pages 37-48) and direct costs (pages 55-57). This list is a comprehensive and useful guide for other studies on this topic.

CALTRANS began contracting out engineering services in 1987. Only a limited number of completed consultant contracts were therefore available for analysis by the Berkeley group. The initial analysis was conducted using 204 in-house projects and 32 consultant projects. The ratio of average engineering design costs to final construction costs was 15.46 percent for the consultant project group and 17.76 percent for the in-house project group using the 144 percent overhead rate. The difference was not statistically significant (at the 5 percent level of significance) however. The sample was further analyzed by size (seven categories based on construction contract dollar amounts), location (metropolitan, urban, or rural), and project type (a very extensive list). These tests also failed to detect a significant cost difference between consultant and in-house projects.

A member of the Professional Engineers in California Government (PECG) responded to the Berkeley study (Blanning, 1992). The PECG group calculated an overhead rate of 118 percent. They were critical of the calculation of overhead rates in the Berkeley study. Moreover, the overhead computation was criticized since it accepted Professional Services Management Journal (PSMJ) data for overhead of consultants and included costs in the in-house overhead computation, which the PECG felt, should not have been included. In addition, the study used 32 consultant jobs and 204 in-house jobs without pairing them to make them comparable. The projects were bundled and compared as groups. Thus, the question arises whether the comparison is meaningful since it may involve projects of different complexity, size and type.

Texas Department of Highways and Public Transportation (SDHPT) Studies. The Texas State Department of Highways and Public Transportation (SDHPT) commissioned three organizations to answer the questions of how the cost and quality of pre-construction engineering services provided by consulting engineers compare with those provided by in-house staff. All three studies were done simultaneously and concluded that the cost of engineering services is lower when using in-house staff instead of consultants.

Ernst and Whinney Study. The first study, conducted by the accounting firm of Ernst & Whinney (E&W), proceeded by evaluating SDHPT's cost charging methods, comparing the costs of project pairs (each consisting of one consultant project and one similar in-house project), and issuing questionnaires about quality to SDHPT personnel (Ernst and Whinney, 1987). Although the report does not directly acknowledge differences between SDHPT's accounting system and that of engineering firms, E&W adjusted the SDHPT's accounting data and overhead calculations to make them comparable to the consulting firm accounting data.

Three measures of design cost were used: the ratio of design costs over construction costs, design costs per plan sheet, and design cost per roadway mile. These three ratios were used to control for variations in the type of projects.

Since only two of the subject projects had reached completion, E&W relied upon questionnaires and interviews to assess project quality. Plan quality and timely performance was also assessed.

The study points out that, besides benefits, in-house overhead costs like supervision, support operations (e.g. personnel, accounting, automation), supplies, office space, utilities and general upkeep should be included. Moreover, such opportunity costs, as taxes paid by consultants should be included in the in-house estimate of overhead costs. These are costs of in-house work since the state is foregoing revenues by using in-house rather than outside services.

Based on ten pairs of projects, the study concludes that the cost of in-house work is less than consultant work. No statistical analysis was conducted. E&W chose to calculate overhead rates for each district rather than a single department (statewide) overhead rate. The four districts were as follows: (1) Beaumont, (2) Corpus Christi, (3) Dallas, and (4) El Paso. The district overhead rates ranged from 75 percent to 93 percent. The report provides detail on the El Paso district only: 79.6 percent total overhead rate, 42 percent of which pertains to salary additives (i.e., benefits).

The E&W study describes a problem in determining the cost of plan work by in-house personnel. *"The difficulty stems in part from the fact that not all in-house personnel who work on plans, charge their time to specific projects; rather they charge an administrative or overhead account"* (page II-2). The major criticism of this study is that the sample was relatively small, and statistical tests were not performed.

Center for Transportation Research Study. The Texas State Department of Highways and Public Transportation asked the Center for Transportation Research (CTR) at the University of Texas at Austin to examine the same issues as those assigned to the firm of Ernst & Whinney (and as the Texas Transportation Institute, below).

CTR proceeded through an examination of accounting methods, global cost comparisons, and quality issues (Ward et al., 1987). Overhead and indirect costs were investigated in detail, starting with an examination of SDHPT's accounting system. In addition, SDHPT's districts and divisions were polled to identify what items should be included in the estimate of indirect costs. Costs for office space were included in the overhead.

CTR concluded that consultant overhead and indirect costs (as paid by SDHPT) were about 45 percent higher than similar overhead and indirect costs incurred by the department. In the study overhead was expressed as the ratio of indirect costs to direct labor cost. In-house overhead rates ranged from 194 percent to 212 percent compared to 286 percent to 307 percent for consultant services (page 37). In addition, the study indicated that consultant salary rates were 5 percent to 22 percent higher than in-house rates (page 41). The salary rate comparison was conducted using 26 consultant projects. The composite weighted average hourly direct labor cost for the consultant projects was $14.44 (page 25). In comparison, the weighted average hourly direct labor cost was $13.72 when in-house wage rates were applied to the mix of hours (among five different skill levels) used by the consultants. In another approach, the study developed a composite weighted average wage rate for 27 in-house projects. This rate was $11.79—22 percent less than the consultant rate. As the study mentions, however, salary additives (benefits) were not included in the salary comparisons (page 27).

A "global" approach was used in that results were developed for the entire group of projects instead of for project pairs. Comparisons were made based on the ratio of the total design cost divided by design wages. Similar to the other Texas studies, quality evaluations were performed on a subjective basis. The study concludes that the ratios of indirect costs to payroll costs suggest that the in-house pre-construction engineering services may be delivered for less cost than consultant's services.

The main criticism of this study was that the analysis assumed that the same mix of employees would be used for the same work by in-house forces and by consultants. Therefore, the wage differential was a factor behind cost differences, if any. Also, bundling the projects in groups raises the question whether the projects were comparable in complexity.

Texas Transportation Institute (TTI) Study. The study by the Texas Transportation Institute's (TTI) at Texas A & M University is the last of the trio of Texas studies. TTI evaluated overhead and other costs based on OMB Circular A-76's cost concept. TTI then made direct comparisons of paired projects, based on the ratio of design cost over total construction cost. The data collected to perform these calculations were transformed via regression analysis into graphs to serve as the basis for a predictive model.

Eighteen pairs of projects (one consultant and one in-house in each pair) were analyzed. The percentage of engineering costs to total construction costs was lower for in-house projects in 15 of the 18 pairs. The average percentage for in-house projects was 2.8 percent and for consultant projects the average was 4.9 percent.

The study relied extensively on interviews with various SDHPT department heads to determine an overhead rate for in-house projects. Only those overhead costs considered not to continue in the event of exclusive use of contracted out services are included in determining the overhead rate. Consequently the costs of many functions are excluded from overhead rate computation. After excluding costs related to budget monitoring, transportation planning, safety and maintenance, administrative support and other costs an overhead rate of 52.97 percent was established. This rate is applied to total direct costs. The study reports consultant overhead rates ranging from 128 percent to 149 percent.

Quality issues were looked at through the use of interviews with consultants and with SDHPT personnel. The finding of the study was that cost of engineering services is lower when using in-house staff instead of consultants. A relatively small number of projects were used in the comparison.

Wisconsin study. A large increase in the use of engineering consultants between 1982 and 1989 led the state of Wisconsin to commission a study on the cost-effectiveness and impact on quality of contracting out design services. The Legislative Audit Bureau of the state of Wisconsin conducted the study (Wisconsin Legislative Audit Bureau, 1990). Overhead rates were calculated based on highway department standards and on OMB standards to produce two independent estimates of overhead rate. The ratio of design costs to total construction costs was again the measure used for project comparison. Though the number of projects involved in the comparisons was not given it is implied to be large given the history of consultant use.

Overhead costs for in-house projects were calculated at a rate of 111.6 percent of direct salary costs using OMB standards and 156.8 percent with highway department standards. The range for consulting firms was from 135 percent to 165 percent. Quality was evaluated using the number of construction change orders and final plan errors.

The study concludes that the use of consultants is no more costly than if the state had used in-house staff. Two reasons for this finding were offered. First, projects given to consultants were less complex, and secondly, in-house projects were not managed efficiently.

Study for the Missouri Highway and Transportation Department. The Missouri Highway and Transportation Department established a team to compare preliminary engineering (PE) design costs for projects performed in-house with projects performed by consultants. The team used three methods of comparison. In Method 1, the total in-house PE design costs to total construction costs for a 19-year period were computed and compared to the total consulting PE design costs to total construction costs for the same time period. In Method 2, two samples of bridge and roadway design projects were selected for in-house and consultant projects, respectively. The ratios of PE costs to total construction awards were compared for the in-house and the consultant jobs. Method 3 compared the salary and associated costs for identical projects if they had been done in-house versus done by consultants.

The results of Method 1 showed that in-house PE was on the average 7.34 percent of construction awards versus 9.62 percent for consultants. Methods 2 and 3 support these findings that in-house design work is more cost effective than consultant design work.

Reviews of Other Studies

All of the studies discussed above are based on samples of projects. There are some other studies that discuss the general pros and cons of contracting out based on aggregate data available from the government and private industry.

Professional Services Management Journal study. Fanning reported in the Professional Services Management Journal (PSMJ) that the cost of professional engineering services as a proportion of construction cost progressively reduced as the proportion of work conducted by consultants increased (Fanning, 1992a and 1992b). Using data collected by Federal Highways Administration (FHWA) from all fifty states for the period 1979-1989, he showed that states that contract out less than 20 percent of their engineering design work have the highest design costs in relation to construction spending. States that contract out between 50 percent and 70 percent of their engineering design work have achieved the lowest ratios of design to construction spending. Specifically, states that contracted out less than 10 percent of their design work had an average ratio of design cost to construction cost of 0.21 while states that contracted out between 50 percent and 70 percent of their design work had an average ratio of only 0.11. No relationship to topography, size of highway system, size of construction program or any other characteristic of the state could be established to explain the relationship except proportion of engineering work conducted by consultants (Fanning, 1992b). According to the FHWA statistics for the years 1979 to 1989, Louisiana, with a 12 percent average design to construction cost, was tied with Wisconsin at the 14th lowest percentage out of 50 states.

Two points are worthy of mention related to this issue. First, many studies found ratios of design cost to construction cost much lower than those quoted by Fanning. The Missouri Highway and Transportation Department study, for example, reports ratios for consultant and in-house staff of 0.096 and 0.073, the TTI study reports values of 0.049 and 0.028, the Ernst and Whinney study reports 0.052 and 0.047 and University of California, Berkeley study reports 0.155 and 0.178. With the exception of the UC Berkeley study, the PSMJ study had considerably higher ratios of engineering cost to construction cost.

Reviewing the data used in the PSMJ study gives rise to a second concern over the completeness of State reporting for the study. The reported ratios among the fifty states varied from 0.45 to 0.06, suggesting a radical difference in reporting among the states. Federal officials also expressed their doubt regarding the completeness of the data (Fanning, 1992a).

Transportation Research Board study. Kenneth E. Cook analyzed a survey that was done by the Transportation Research Board in 1984. Although this survey is dated, it contains several issues pertinent to the decision of whether to contract out or not. The main reasons for use of contractors given by the 40 states responding to the survey, in order of importance, were:

- To respond to increased or peak work loads without increasing the number of in-house staff,
- To gain the services of trained professionals and specialized equipment,
- To replace mandated staff reductions,
- To make use of all available funds,
- To reduce costs,

- To provide opportunities for private contractors, and
- To improve agency credibility with the public and to respond to the desire for less government.

A number of common problems related to the use of contractors and consultants were reported by the states. First, a loss of direct control over the activity was frequently indicated. Once a project is assigned to a consultant, the ability to reassign resources or alter schedules is limited. A second problem identified through survey was that the contracting-out process takes too long and, therefore, it is difficult to get jobs started and completed on time. More time is needed for the contractor to schedule the job along with other work. Moreover, change orders are difficult to handle with contractors.

There are also legal considerations arising from contracting out for services. While the contractors are usually required to carry public liability and property damage insurance, States attempt to avoid such liability by including in all contracts a “hold harmless clause” under which the state will not be held liable for the actions of the contractor. Nevertheless, the State remains a primary target for litigation because of its size, resources, and permanent existence.

The survey indicates that most states do not use cost comparison as a reason for contracting out. They consider other factors to be more important and suggest that internal overhead rates are not sufficiently accurate to permit meaningful comparisons among in-house and consultant design costs. Most of those states which use cost comparison, include costs on direct labor, fringe benefits, and equipment rental charges and exclude other overheads such as utilities, insurance, support services, and capital depreciation.
Concern was expressed by the responding states that contracting out to reduce in-house staff may result in the loss of engineering design skills at DOTs. This could hamper their ability to check and evaluate consultant’s design work.

Studies among city and county workers. Concentrating on employment effects, a report of the National Commission for Employment Policy, Privatization and Public Employees provides a review of the impact of privatization on city and county workers (Dudek, 1988). While the study specifically relates to privatization of non-professional services, several issues are raised which have a bearing on this study.

Although most government workers find jobs elsewhere, there is a job displacement effect from contracting out. Public assistance may be needed to help displaced public employees. Moreover, wages paid by private firms is generally lower than wages paid by the government.

Fringe benefits differ for the government and the private sector. A private contractor's employees generally have less vacation time, lower rates of absenteeism, are a younger workforce, and use less labor-intensive production techniques than a government agency workforce.

A study by Handy and O’Connor (1984) about the use of labor between government agencies and private contractors points out several other characteristics in the use of labor by contractors. Their research found that private contractors compared to government agencies use supervisors to perform direct labor, rely more heavily on multi-skilled workers, use lower-skilled workers, are inclined to cut out unnecessary work, allow more overtime, use more part-time workers, and are less constrained in hiring and firing workers.

Internal DOTD cost comparison. The DOTD conducted an internal investigation (DOTD, 1996) to estimate in-house versus consultant cost of engineering design services in 1996. In this study several (31) bridge projects were identified for investigation. Two in-house projects and one consultant project were analyzed. In general, the study could draw criticism of objectivity because it was done in-house. In addition, the sample size was much too small to draw valid conclusions.

In-house projects. 1) Red River Bridge @ Moncla Final Bridge Plans Main Span (SP 33-03-0033, 700-30-0208). The design for this project was performed in-house. The direct payroll cost for the 4177.5 hours obtained from time sheets was $74,344. The direct payroll cost was based on estimated hourly wages of employees involved in the project. The overhead rate was computed using the sum of all non-project charges including charges to the following object codes:

- 102 annual leave taken
- 103 sick leave taken
- 104 compensatory leave taken
- 105 other leave taken
- 106 compensatory leave paid
- 109 educational leave
- 112 retirement benefits
- 113 federal insurance contribution
- 114 Medicare tax
- 115 group hospital & life insurance
- 118 one-time pay bonus

The total direct payroll cost was divided into the indirect charges resulting in an overhead rate of 141 percent. For the given project an indirect cost of $104,825 was obtained. Adding direct expenses of 3,650 hours, the total in-house fee was thus computed at $182,819. Given a construction cost of $12,520,778, the ratio of total design cost to construction cost was 1.46 percent.

Based on actual plan sheets developed in-house, the consultant design man-hours were estimated using the DOTD “Engineering Service Contract Fee Calculation” program. The estimated hours were 4099, which is slightly below the in-house recorded hours. These man-hours were multiplied by the average hourly pay rate obtained from a statewide survey of hourly wage rates for consultants. The direct payroll estimated for consultants was $72,916. A state average overhead rate of 133.23 percent for consultants was added. The same direct expenses were added as actually occurred in-house. The subtotal was escalated by a factor 1.0484, and a contingency of 10 percent was added. Finally a profit of 15.61 percent, representing a statewide average, was added. The total, $228,762, was adjusted by a 5 percent administration fee, which resulted in a total of $240,450 or 1.92 percent of construction cost.

2) Saline Bayou & Relief Bridge (SP 001-06-0042, 700-23-0074). The Saline Bayou project was initiated in 1986 and constructed in 1994. The approach taken to estimate cost for in-house and consultants were the same as for the Red River project. Hence only items which appear to be different from the Red River project are discussed. The in-house hours recorded for the project were 1,441 while the estimated hours for consultants using the same method as described in the Red River project resulted in 3,046 hours. The total in-house fee including overheads was reported as $67,496. However, because of a computational error the true total fee is only $49,952, which is 3.2 percent of construction cost. The estimated engineering cost for consultants using the 3,046 hours was $146,000 or 9.76 percent of construction cost.

Consultant project. The Dodson Sikes Highway (SP 09-07-0014, 700-23-0072). This project was initiated in 1986 and constructed in 1994. Consultants performed the design work for a lump sum fee of $150,926. An administrative cost of $7,518 was added to this lump sum. These administrative costs were obtained from departmental records of Sections 18, 24 and 25. The total cost of the consultant's design added up to 10.4 percent of construction cost.

Using the same man-hours used to estimate the lump-sum payment for the consultants, a direct in-house payroll cost was estimated. The direct in-house payroll was estimated as $55,428. Assuming an overhead of 143 percent and adding direct expenses of $1,850, a total of $136,541 or 8.95 percent of construction cost was estimated. This calculation is without applying the escalation factor used in the consultant's cost estimation. When the same escalation factor is used in-house as was applied to the consultants the total costs for engineering design are $146,345 or 9.59 percent of construction costs.

Critique of the method. The Louisiana DOTD uses a formula for the consulting fee calculation. This allows simulating consulting fees for in-house projects. However, this comparison relies on several assumptions, which may or may not be fulfilled. Each assumption is discussed below.

The in-house man-hours are taken from records while the consulting man-hours are estimated based on plan sheets. A comparison assumes that the recording of in-house hours is accurate. This may not be the case as the Saline project suggests. There, the in-house recorded hours were 1,441 while the estimated consulting hours were 3,046. If these data were correct it would imply that a project could be done in less than half the time consultants were allocated. Although this may be possible, the discrepancy is more likely due to incomplete recording of in-house hours.

The in-house records do not show the direct charge of any supervisors while the computation for consultants include the use of supervisors. If the in-house supervision is not charged to projects it will be part of the overhead cost and thus inflate overhead cost.

Another problem is the time when the hourly wages were applied. The consulting cost computation uses 1991 salary data while the in-house salary data are supposedly from 1996.

Hence, additional escalation factors need to be used to adjust for the different years of in-house hourly rate and consultant projects hourly rates.

The in-house overhead calculation is based on estimates of overhead rates from accounting data. There seems to be consensus in the literature that overhead rates should include cost on direct labor such as fringe benefits as well as other indirect cost such as utilities, and support services. However, the overhead calculations for the two in-house projects above do not include support services and utilities. This exclusion will tend to underestimate the overhead rate.

It is not clear whether the administration fee of 5 percent is a correct measure of DOTD's involvement in consulting projects. The use of a specific rate needs to be supported by data. In the simulation of in-house cost for consulting projects the assumption is made that the man-hours for in-house are the same as for consultants. In-house data need to be used to verify this assumption.

Summary of Past Study Findings

Table 1 summarizes the aforementioned studies, together with other studies reviewed by Wilmot (1995).

Table 1
Summary of past study findings

Study	Cost	Quality
Roy Jorgensen & Associates, 1977	Consultants 100% more expensive.	N/A
Western Association of State Highway and Transportation Officials, 1979.	11 states (83%) said consultants are more expensive. Two (17%) said costs are the same.	8 states (62%) said consultant's quality of work inferior to in-house staff, 5 (38%) said quality is the same.
Maryland DOT, 1981.	Consultants 80%-120% more expensive.	N/A
Transportation Research Board, 1984	Consultants are not cheaper.	N/A
Vermont Department of Transportation, 1986.	Consultants 16%-240% more expensive.	N/A
Center for Transportation Research, University of Texas, Austin, 1986.	Consultants more expensive.	Quality the same.
Texas Transportation Institute, Texas A&M University, 1986.	Consultants more expensive	Quality the same.
Ernst and Whinney, 1986.	Consultants generally more expensive.	Quality the same.
Alabama Department of Transportation, 1989.	Consultants 69% to 100% more expensive.	N/A
Professional Services Management Journal, 1990?	Consultants cheaper than in-house staff.	N/A
North Carolina DOT, 1990.	Consultants more expensive.	N/A
Wisconsin Leg. Audit Bureau, 1990.	Cost the same.	Quality the same.
Michigan DOT, 1991.	Consultants 33% more expensive.	N/A
Univ. of California, Berkeley, 1992.	Cost the same.	N/A
Legislative Analyst, California, 1993	Consultants more expensive.	N/A
Missouri Highway and Transportation Department 1993.	Consultants 31% more expensive. In survey of 10 states, 8 said consultants more expensive, 2 said costs were the same.	N/A

N/A: Indicates "not available" because not included in analysis.

Table 2 summarizes the overhead rates determined in past studies. The overhead rates quoted in the table are all of the so-called "unburdened" overhead rate type, meaning that they are calculated by dividing total indirect costs, including benefits, by direct labor costs. As can be seen, the overhead rates vary widely (75 percent to 307 percent) confirming how differently overhead rates can be interpreted even when the same basic definition is being used.

Table 2
Literature review comparison of overhead rates

Study	Overhead Rates	Overhead Allocation Basis
California DOT (Berkeley)	145% 155% 175%	Direct Labor Costs (Unburdened)
California DOT (PECG: Reply on Berkeley Study)	118%--In House 147% --Consultant	Direct Labor Costs (Unburdened)
Texas State Department of Highways & Public Transportation (Ernst & Whinney)	75% to 93%	Direct Labor Costs (Unburdened)
Texas State Department of Highways & Public Transportation (CTR)	194%-212%--In-house 286%-307%-- Consultant	Direct Labor Costs (Unburdened)
Texas State Department of Highways & Public Transportation (TTI)	52.97%	Direct Labor Costs (Unburdened)
Wisconsin Legislative Audit Bureau	111.6% ('avoidable rate') 156.8% (full absorption rate)	Direct Labor Costs (Unburdened)

Conclusions

The majority of the work in the field of engineering design cost comparisons between in-house and consultants has concentrated on samples of projects and used available accounting data to determine cost differences. This has usually taken the form of direct cost comparisons and overhead rate examinations. As shown in Table 1, most studies have found consultants to be more expensive than their in-house counterparts. While direct project charges have generally been taken straight from accounting databases, overhead rates have been more critically examined with regard to their composition. As shown in Table 2, in-house overhead rates vary considerably from study to study. While in-house versus consultant costs have been compared on many criteria, the ratio of design costs to construction costs seems to be the most popular approach.

The studies reveal several inherent problems with comparing in-house versus consultant design cost. These problems can be summarized in the following points:

1) *What cost should be included in the in-house overhead cost estimate?* For instance, some studies (e.g. Ernst & Whinney) base their analysis on avoidable costs, while other studies

(e.g. Berkeley, University of Texas Center for Transportation Research, Wisconsin Legislative Audit Bureau) take a broader approach. The avoidable cost approach uses a marginal cost analysis, i.e., what costs would occur if one project would be contracted out versus done in-house. Avoidable costs, in this case, are lower than if the question asked was whether or not all projects should be done in-house versus contracted out. Between 1988 and 1996, for example, Louisiana DOTD had $132,964,730 in consulting engineering contracts completed. The Louisiana DOTD would not have been able to perform these projects with the present in-house staffing. Hence, additional personnel would have to be hired, offices rented, office supplies and equipment purchased, etc. Some of these items are excluded when only marginal costs are analyzed. A broader view, therefore, is to use an average cost approach where all costs that are necessary to run a department are included in the overhead.

2) *The in-house overhead charges are not sufficiently accurate to draw reliable conclusions.* The main problem is that in-house non-project charges are usually very high. These non-project charges may include items such as:
   - administration,
   - administrative supervision,
   - special projects for the legislature, and,
   - time which should have been charged to projects.

   The third item needs to be taken out of the overhead computation, while the fourth item should be included in the direct charges. In most cases this is a difficult task that may require interviews as done by the Texas Transportation Institute for the Texas study.

3) *To draw valid conclusions comparable in-house and consultant projects must be chosen.* It is generally difficult to find comparable pairs of consultant and in-house projects. Even when project pairs are found, the randomness of the sample is in question and thus the conclusions may be invalid. Cost differences may be due to other factors such as complexity of the project. The formula used to estimate consultant projects in the Louisiana DOTD provides an opportunity to obtain in-house and consultant cost estimates for the same project thus alleviating the problems of finding pairs of comparable projects.

4) *The sample size has to be sufficiently large to allow statistical testing.* In many studies the sample was not only nonrandom but also too small to draw reliable conclusions. If information is available in a database it may be used to extract a larger sample to be analyzed.

5) *Other factors should be considered beyond the cost comparison when decisions are made whether or not to contract out.* These factors include the following:
   - Quality of work performed.
   - Delay cost when contracting out.
   - Downstream economic effects.
   - Opportunity costs.
   - Governmental policy.

- Maintaining expertise and experience among in-house staff.

However, most of these factors are very difficult, if not impossible, to assess.

ANALYSIS OF DOTD ORGANIZATIONAL STRUCTURE AND SYSTEMS

Review of DOTD Organizational Structure

The purpose of this task is to identify the DOTD staff elements involved with providing pre-construction engineering design services and to quantify the extent of their involvement. As shown in Figure 1, the DOTD is divided into six Operations Staff Directorates. These are:

- Section 10: Management and Finance
- Section 64: Public Works and Flood Control
- Section 20: Engineering and Program and Project Development.
  (As shown in Figure 1 this section also includes the supervisory elements of the Program Management and the Engineering Design and Contract Management staffs that supervise subordinate sections.)
- Section 53: Construction and Maintenance
- Section 12: Research and Planning
- Section 23: Real Estate

In addition to these operational sections at the directorate level, there are six Special Staff sections, seven Boards and Authorities, and nine Districts. These perform duties unrelated to road and bridge design activity at DOTD headquarters and are, therefore, not considered relevant to the cost analysis in this study.

DOTD Staff Elements Involved with Pre-Construction Engineering Design Services. Each of the six operational directorates has several sections. However, only the Engineering and Program and Project Development Directorate (Section 20) has sections involved with providing pre-construction engineering design services. These are:

- Section 25: Bridge Design
- Section 24: Road Design
- Section 80: Design Support Branch
- Section 27: Geometric Design
- Section 29: Hydraulics
- Section 67: Soils
- Section 82: Engineering Support Branch
- Section 28: Environmental
- Section 30: Location and Survey
- Section 39: Contracts and Specifications
- Section 18: Consultant Contract Services

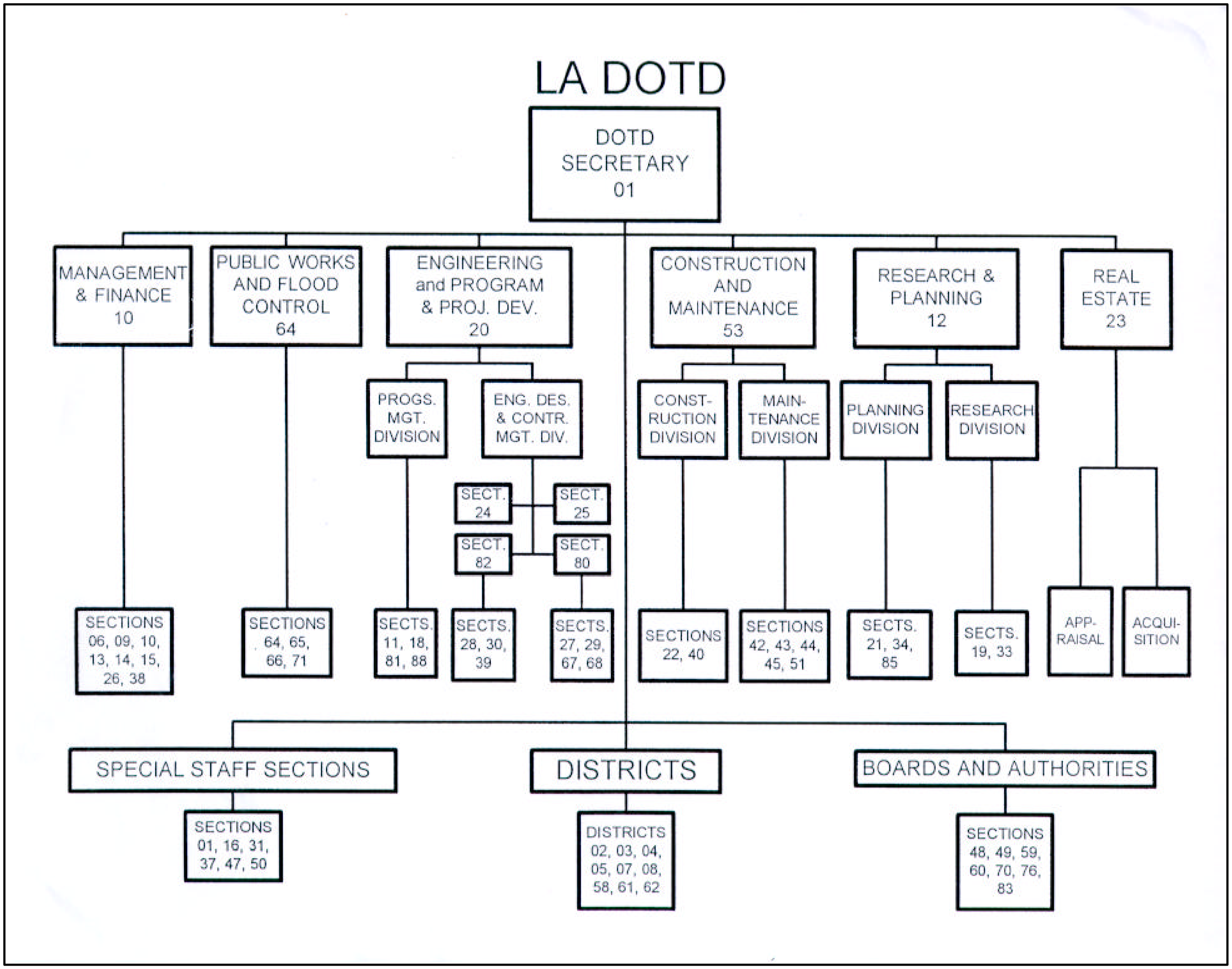

Figure 1: Organizational Chart of DOTD

Sections 25, 24, and 80 focus on in-house services. Section 18 administers the contracts with consultants. Sections 27, 29 and 67 provide services used by both in-house design staff and consultants. Section 20, the Engineering and Program and Project Development Directorate, oversees both the in-house and consultant pre-construction engineering design services provided by the DOTD. Section 82, with its subordinate Sections 28, 30, and 39, provides pre-construction engineering design services that are insignificantly affected by whether the project is designed in or out of house. Accordingly, they are omitted from further analysis.

Section 27 (Geometrics) provides services for in-house as well as for consultant projects by checking the preliminary and final designs. Discussions with the DOTD indicated that this section would provide about the same level of work regardless of whether a design was done in-house or by consultants. The costs of Section 27 were included in this analysis.

Hydraulics and Soils (Sections 29 and 67, respectively) may be contracted out or done in-house. However, the tasks performed in these sections may be considered a phase of the project that precedes actual design or, at least which impacts in-house and consultants equally. For this reason, the costs of Sections 29 and 67 were not included in this analysis.

The extent to which DOTD staff are directly involved in design varies greatly. The amount of direct labor time charged to design services as a percentage of total labor time reveals the degree of involvement of the various sections. Accounting records for the period 1995 to 1996 have been analyzed for this purpose, and the results are presented in Table 3.

The values in Table 3 reflect the time staff charged their time to a project as a proportion of total work time including all leave time. Usually, in private practice this statistic is calculated as a proportion of work time, excluding leave time, as a measure of the level of productivity achieved within that time that the staff are available to work. Leave time for consultants was not available to the study team, but it is believed to be considerably less than that enjoyed by in-house staff. This would serve to deflate the percentages of in-house staff relative to those of consultants.

From the audits of consultants conducted by the department, the charged time of consultants as a percentage of total worked time, including leave, was estimated for a similar period. The results are shown in Table 4. The average, as can be seen, is in the low sixties, although the range is 41 percent to 87 percent among individual consultants in specific years.

Table 3
Percent DOTD labor costs charged to design

DOTD section number (description)	1995-96 percent labor costs charged to projects	Number of employees (as of August 1997)	Labor associated with designs conducted by
20 (Engineering & Program & Project Development)	13%	4	In-House and Consultants
18 (Consultant Contract Services)	39%	10	Consultants
25 (Bridge Design)	48%	57	In-house
24 (Road Design)	52%	57	In-house
27 (Geometrics)	59%	7	In-house and Consultants
29 (Hydraulics)	36%	12	In-house and Consultants
67 (Soils)	56%	11	In-house and Consultants
Weighted Average by Employee Totals	48%		Both

Table 4
Percent consultant labor costs charged to design

	1994	1995	1996	1997
Average percent labor costs charged to design	63%	64%	61%	63%

Given DOTD's broad mission, size, and range of activities, it is not surprising that its chargeable rate is less than the consultant rate. Nevertheless, the chargeable rates of the various sections should be increased to more closely match consultants.

Review of DOTD Accounting System

DOTD's account coding system is extensive and provides a description of departmental expenditures based on object and function codes. There are two numbers which may identify a project. These are the construction number and the engineering number. The construction number consists of a nine-digit sequence. The first five digits describe the control section that identifies a section of roadway, a building, rest area or airport. However, this applies only for state projects. Projects done in the districts have numbers beginning with 713 and 742. The last four digits are the job number, which is merely a sequential number identifying a discrete project.

The engineering number is identified by another nine-digit number. Design projects that are contracted out or performed in Section 25 (Bridge Design) are assigned numbers where the first three, leftmost, digits describe the type of work (e.g., 700 for engineering design), the middle two numbers (4 and 5) indicate the geographic district where the work is to be done, and the final four, rightmost, numbers reveal the consecutive number of projects in that district. In-house and consultant design costs are charged to the engineering project number.

Design projects that are done in-house in Section 24 (Road) are not assigned an engineering number. Rather, the in-house design efforts of Section 24 are charged to the construction number of the project. DOTD employees are required to fill out a weekly time sheet where the amount of time spent on design projects is itemized.

All expenditures charged to a project have a three-digit function code to describe the type of work performed. The following partial list of function codes illustrates some of the descriptions commonly used to describe various engineering design charges:

- 017 Preliminary Design & Plan Preparation
- 026 Final Design & Plan Preparation
- 058 Initiate Consultant Projects
- 060 Supervise Consultant Design

The following Tables 5 to 7 show the costs not charged to projects in 1996 and 1997 by function codes (excluding codes 802 to 819 which relate to fringe benefits) for Sections 18, 24, and 25, respectively.

Table 5
Non-project charges in Section 18
(consultant contract services) in 1996 and 1997

Code	Description	Cost 96	Cost 97
58	Initiate Consultant Projects	$ 2,178	$ 1,108
820	Adm. Officials, Section Head, Clerical, General	$ 57,556	$ 72,995
899	Payroll Adj.	$ 305	$ 937
910	Administrative Engineering	$ 51,294	$ 43,351
920	Engineering General Functions		$ 1,823
	Total	$ 111,333	$ 120,214

Table 6
Non-project charges in section 24 (road design) in 1996 and 1997

Code	Description	Cost 96	Cost 97
2	Studies	$ 152	$ 643
17	Preliminary Design & Plan Preparation	$ 867	
20	Preliminary Engineering Incidental Adj. FHWA Project	$ 426	
26	Final Design & Plan Preparation	$ 950	
58	Initiate Consultant Projects	$ 779	
60	Supervise Consultant Design	$ 2,087	$ 1,716
820	Adm. Officials, Section Head, Clerical, General	$ 203,444	$ 198
824	Annual Leave Paid	$ 2,085	$ 16,794
828	Legal Supportive Services	$ 9,694	$ 473
835	Training—Administrative Personnel	$ 689	
899	Payroll Adj.	$ 6,449	$ 3,378
910	Administrative Engineering	$ 131,823	$ 109,127
920	Engineering General Functions	$ 178,287	$ 304,904
931	Training—Engineering Personnel	$ 6,199	$ 1,006
	Section 24 Total	$ 543,932	$ 438,239

Table 7
Non-project charges in section 25 (bridge design) in 1996 and 1997

Code	Description	Cost 96	Cost 97
2	Studies	$ 165	
17	Preliminary Design & Plan Preparation	$ 431	$ 292
26	Final Design & Plan Preparation	$ 5,394	$ 2,763
29	Development & Maintenance of Standard Plans	$ 41,196	$ 36,636
56	Revise Completed Plans		$ 252
60	Supervise Consultant Design	$ 930	
67	Checking	$ 8,440	
73	Evaluate Structural Bridge Capacity & Set Weight Limit	$ 209	
74	Maintenance Related Engineering Services		$ 140
95	Prepare Permit Applications	$ 19,325	$ 16,573
249	Construction Related Engineering Services	$ 450	
820	Adm. Officials, Section Head, Clerical, General	$ 66,736	$ 48,364
824	Annual Leave Paid	$ 18,912	$ 7,138
828	Legal Supportive Services	$ 2,091	$ 722
835	Training—Administrative Personnel	$ 2,065	
899	Payroll Adj.	$ 4,661	$ 5,684
910	Administrative Engineering	$ 252,548	$ 243,793
920	Engineering General Functions	$ 258,896	$ 219,049
931	Training—Engineering Personnel	$ 740	$ 845
	Section 25 Total	$ 683,191	$ 582,249
	Grand Total	$ 1,338,456	$ 1,140,702

The majority (70-80 percent) of the non-project charges for the three sections in Tables 5 to 7 are to Function Codes 820 (Administrative Officials, Section Head, Clerical, General), 910 (Administrative Engineering) and 920 (Engineering General Functions). Interviews with DOTD staff suggest some portion of these charges arise because DOTD must respond to a variety of requests from constituencies and governmental officials. While there is substance to this suggestion, there is no evidential material to assess the magnitude of such involvement.

In summary, the accounting system allows in-house data to be obtained for projects by function codes. Function Codes 17 and 26 allow assigning cost for preliminary and final designs, respectively. The accounting system does not provide more detailed information such as cost for preparing individual plan sheets.

The DOTD Information System

There are several databases available within DOTD to provide information on design and construction projects. These are:

- The Tracking of Projects System (TOPS)
- The Letting Schedule System (LETS)
- The BIDS System for Contract Information and Contract Items
- The Accounting System

Each of the above systems provides different information about a project. TOPS provides information relating to the different phases the project goes through from design to final acceptance. The LETS system, concentrating on aspects relating to the letting of the contract, does include information about the estimated construction cost, the final construction cost and whether consultants or the DOTD did the engineering work. BIDS provides detailed information on the bidding conducted for the construction phase. However, no system gives all the information needed to determine engineering design costs paid to consultants. There is a field for the engineering cost in the TOPS database; however, the field is not used to record the correct engineering cost. To obtain consulting engineering cost, the engineering project number has to be obtained from the TOPS system. This can be achieved by entering the construction number in the TOPS system. A screen will provide the engineering number. Since engineering consulting costs are not available on any computer system, the payments made to consultants for design services must be obtained from a ledger maintained manually.

The accounting system provides information about in-house charges to engineering design projects. However, the system also does not allow easy access to pertinent project information. Queries have to be submitted to the computer center for processing on a batch process.

To test the consistency of in-house project charges over several years, data from the accounting system for the last two budget years, 1996 and 1997, were obtained. Tables 8 to 10 below show the percentage non-project charges by individual cost item or gangs in Sections 18, 24, and 25 respectively. Gangs are small work units within each section that are assigned to various projects. Gang 2 percentages in Section 24 include adjustments to remove charges for legal support services. Gang 3 and 9 percentages in Section 25 have been adjusted to account for Function Code 29 (Development & Maintenance of Standard Plans) and 95 (Prepare Permit Applications) charges.

Table 8
Section 18 Consistency of in-house non-project charges

Gang Number	1997	1996
1	67%	62%

Table 9
Section 24 Consistency of in-house non-project charges

Gang Number	1997	1996
Administration	98%	99%
2	75%	71%
11	46%	44%
12	34%	44%
13	51%	44%
14	35%	37%
21	46%	45%
22	45%	42%
23	43%	40%
24	56%	40%
31	31%	31%
32	39%	38%
33	33%	36%
34	39%	38%
42	28%	42%
501	9%	53%
502	42%	42%

Table 10
Section 25 Consistency of in-house non-project charges

Gang	1997	1996
Administration	100%	100%
2	48%	43%
3	46%	39%
4	45%	49%
5	46%	58%
6	66%	50%
7	47%	46%
9	35%	41%

The average non-project charges that Section 18 experienced was 62 percent in 1996 and 67 percent in 1997. The tables show that the non-project charges vary considerably between gangs but that there is considerable consistency within gangs from year to year. Section 24 had average non-project charges between 28 percent and 75 percent, while the average non-project charges for Section 25 were between 35 percent and 66 percent, not counting administration.

Gangs 4 and 9 in Section 25 and Gang 31 in Section 24 are considered experimental in that time sheets are input directly into the computer on a daily basis. Other gangs hand in a hard copy of their time sheets at the end of each week. The three gangs submitting timesheets on a daily basis have among the lowest percentage non-project charges. Their non-project charge percentages are comparable to consultant engineering firm rates, as derived from the chargeable percentages for consultants in Table 4.

METHODOLOGY

Methodologies Applied in Other Studies

The objective of this task is to develop the methodology to compare the cost of providing pre-construction engineering design services to Louisiana DOTD when these services are provided by in-house staff or by consultants.

As discussed in the literature review, past studies have shown that it is difficult to measure design costs accurately. Cost items can vary among in-house and consultant projects, and it is difficult to assess what portion of the cost of some items is attributable to design and what portion is not. For example, taxes are a cost item among consultants but not in state DOTs. Liability insurance is present among both, but costs are typically higher for state DOTs because they carry the added liability of ownership of the facilities they administer. In addition, it is a difficult decision as to how much of upper management costs and which support services, including associated departments such as the Department of Administration, are associated with design costs. To add to these difficulties the type of projects and their complexity and size also affect any costs comparison. As the analysis of DOTD projects below shows, the cost for design as percent of construction cost varies significantly.

Past studies have addressed these issues in a variety of ways but have all conceded that it is ultimately impossible to get a definitive assessment of comparative costs. The comparisons must be seen as assessments based on assumptions that are the best attempt at establishing an equitable comparison among in-house and consulting conditions. Some of the ways in which past studies attempted to establish more equitable conditions include:

1) The pairing of projects to eliminate the effects of type of project,
2) Using the ratio of design cost over construction cost to eliminate the effect of the size of the project, and
3) Sampling to establish similar mixes of projects among those designed by in-house staff and consultants and to ensure that the results are representative.

The cost items included and the estimates of their magnitude have been a matter of contention in most studies.

Description of DOTD Engineering Projects

After a need has been identified, a DOTD engineering project typically begins with planning and conducting a preliminary investigation to determine whether further work is warranted. The preliminary work entails site inspection and initial engineering report activities. After a construction project is included in the Highway Priority Program, it is also included in the State Transportation Improvement Program (STIP). An Environmental Impact Study (EIS) lasting 12 to 24 months is then conducted. Although the Environmental Impact Study may also be contracted out, it is not part of this comparative cost study. Once the EIS has been completed, design is initiated in accordance with established design criteria. The DOTD then decides whether the design work should be done in-house or by consultants. Design typically includes preliminary and final design phases, followed by construction. The decision to contract out the design is made on a case-by-case basis. The decision is influenced by the availability of in-house staff, technical expertise, project size, and other factors.

The DOTD's Letting Schedule (LETS) database shows a total of 724 construction projects let in the budget years 1995-1997. These are summarized in Table 11. The majority (548) of the design projects were performed in-house with most (308) being overlay projects. Only 147 were bridge or road design projects involving more than rehabilitation of the surface of the road. Among the 176 projects marked as consultant projects in the LETS database, many designs were conducted for the district offices of DOTD. Since this study does not consider projects designed in the districts, such projects were excluded from the sample.

Table 11
Projects let in budget years 1995-1997

Type	Count	%	Cumulative
Overlay	308	43%	43%
Microsurfacing	28	4%	46%
Chip Seal	26	4%	50%
Surface Treatment	19	3%	53%
New Bridge	64	9%	61%
Bridge Replacement	46	6%	68%
New Bridge Structure	10	1%	69%
New Road	14	2%	71%
Widen Road	13	2%	73%
Other	196	27%	100%
Total	724	100%	

Table 12 depicts the 73 remaining projects, which served as the population from which samples of in-house and consultant projects were drawn for analysis.

Table 12
DOTD design projects: 1995-97

No.	Eng#	Constr#	Bid	Consultant	In-House	Grand Total
1	700230074	1060042	$1,570,860		$46,757	$46,757
2	700270055	3100011	4,720,274		135,384	135,384
3	700240082	5010056	6,157,715	$139,765	260,892	400,657
4	700390101	8020025	1,326,521		66,225	66,225
5	700230090	9300007	1,495,646		35,948	35,948
6	700220003	22020028	3,167,176	62,958	121,769	184,727
7	700200077	22030034	4,305,949		159,437	159,437
8	700220004	22030035	3,359,621		82,108	82,108
9	700260042	23010037	10,435,000	411,640	98,585	510,225
10	700220053	31020014	4,497,616		124,130	124,130
11	700270012	33030032	9,651,000		259,762	259,762
12	700300208	33030033	12,520,778		257,636	257,636
13	700220059	38010025	874,280		47,594	47,594
14	700110024	39030011	3,409,886		240,615	240,615
15	700110024	39030014	3,409,886		211,356	211,356
16	700110024	39030014	7,060,869		211,356	211,356
17	700230076	41010030	2,734,795		212,659	212,659
18	700230091	41020026	573,359		33,822	33,822
19	700200070	47020022	8,258,262		231,945	231,945
20	700170062	56070010	2,209,059	187,170	17,765	204,935
21	700110007	62030007	9,526,260	255,488	40,581	296,069
22	700230043	69030013	2,281,466		66,781	66,781
23	700230094	69040012	1,213,695		124,373	124,373
24	700170078	77040015	5,034,625	191,914	73,007	264,921
25	700230072	91070014	1,526,216	348,001*	20,114	368,115
26	700240053	113010011	3,086,122		133,470	133,470
27	700200069	116020005	1,029,728		132,490	132,490
28	700240029	117010018	1,074,508	89,452	12,032	101,485
29	700230079	123030007	376,121		32,190	32,190
30	700220009	126010017	3,785,359		93,067	93,067
31	700100023	133020030	2,495,987	517,258	26,947	544,205
32	700220021	133030008	3,245,802		132,179	132,179
33	700220038	134040012	1,151,383		82,760	82,760
34	700200090	135010012	957,908		66,249	66,249
35	700230096	139040014	3,524,575		162,851	162,851
36	700220089	149020008	757,249		16,926	16,926
37	700190042	156010009	7,787,141	278,556	42,661	321,216

* Includes cost of survey

Table 12 (contd.)
DOTD design projects: 1995-97

NO.	Eng#	Constr#	Bid	Consultant	In-House	Grand Total
38	700290045	186010010	$914,792		$37,914	$37,914
39	700230077	187010027	560,965		28,110	28,110
40	700250029	211030004	993,616	$56,983	24,117	81,100
41	700230098	211300011	1,890,050	106,983	69,854	176,837
42	700210073	218010012	1,931,173		94,164	94,164
43	700180031	248020027	4,465,312	73,471	284,955	358,426
44	700300070	260010016	1,140,758		54,410	54,410
45	700200040	260050020	8,886,029		293,486	293,486
46	700190057	262040005	10,598,601	505,177	79,053	584,230
47	700270037	268010012	5,395,000		256,108	256,108
48	700220017	321010013	1,851,295	100,053	14,945	114,998
49	700220007	378030006	2,308,987		69,111	69,111
50	700230099	389010009	623,437		30,021	30,021
51	700220031	390020008	366,222		23,307	23,307
52	700180098	413010011	1,585,744	139,754	32,517	172,271
53	700290066	417020023	9,138,060	272,957	33,685	306,642
54	700160037	424070018	6,145,078	461,715	92,750	554,465
55	700260014	450910077	24,088,000		239,412	239,412
56	700240070	451030043	2,388,088		6,459	6,459
57	700290044	454010054	41,233,209	2,164,134	161,109	2,325,243
58	700230025	815140010	1,483,531		71,252	71,252
59	700250020	817400004	5,491,587	115,415	29,202	144,617
60	700180085	828390021	6,141,098	254,754	36,463	291,217
61	700230046	828440012	254,426		27,195	27,195
62	700290108	829260005	3,700,000		20,994	20,994
63		829310001	1,107,689		23,989	23,989
64	700220022	830190005	653,151		110,907	110,907
65	700230085	835100010	719,953		73,679	73,679
66	700170061	837040014	4,092,281	176,309	45,908	222,217
67	700240005	840120004	463,480		39,511	39,511
68	700240003	840130004	1,173,119		128,296	128,296
69	700240008	843010010	1,665,692	16,367	27,430	43,797
70	700270058	849260012	2,082,586		38,933	38,933
71	700240032	853260007	820,625		94,764	94,764
72	700240058	858080008	266,234		21,880	21,880
73	700240096	863020020	1,422,817		149,736	149,736

The table gives the engineering number, construction number, the bid for construction; consultant cost for design and in-house cost from the accounting system including Sections 18, 24, 25, 27, 29, 67 and 68. The costs were obtained from several sources. The in-house cost was obtained from the accounting system. The reliability of these costs depends on the accuracy of the in-house charges to the projects. The consulting costs are not available on the DOTD's information system. They were obtained from a ledger kept manually by a DOTD employee. However, some of the consultant cost could not be found due to a convoluted way of keeping cost in the manual ledger. Although the consultant costs are entered into the manual ledger by project number, some of the projects are listed with different project numbers thus making it impossible to find costs in some instances. Therefore the consultant costs listed in Table 12 may not be complete. Also, consultants cost may or may not include survey costs. No function code is available which identifies the type of consultant work.

Figure 2 shows the ratio of engineering design cost over construction bid price. Only 37 (51 percent) of the 73 projects had a ratio less than 5 percent. Twenty-five projects had a ratio between 5 percent and 10 percent. Eight projects had a ratio larger than 10 percent. The chart shows that this ratio has a large variation and is, therefore, not an adequate measure for comparing in-house versus consultant engineering cost.

A sample was drawn from the 73 projects for analysis. The sample sizes are given in parentheses in the bars in Figure 2. As can be seen, the sample is similarly distributed to the population.

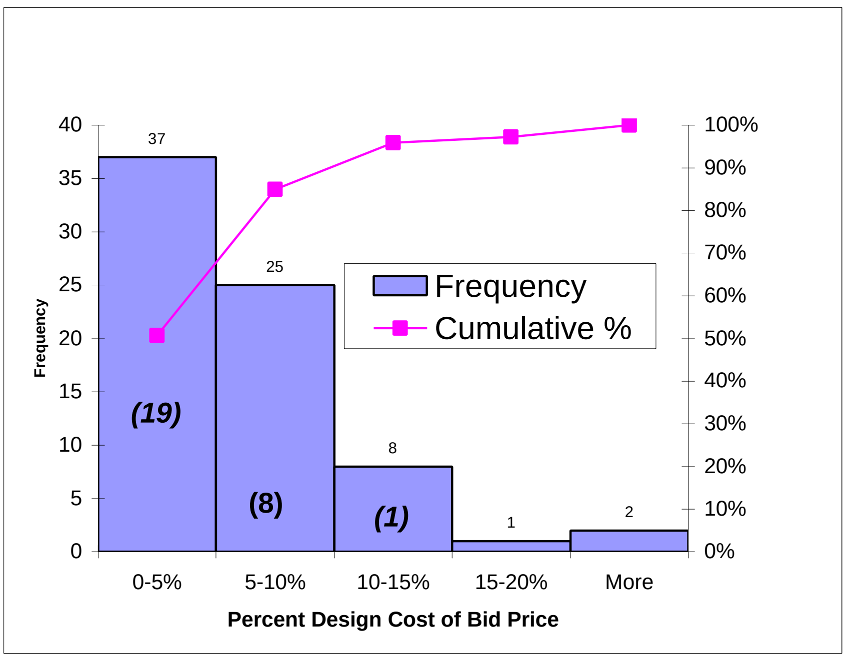

Figure 2
Frequency of design cost to construction bid price

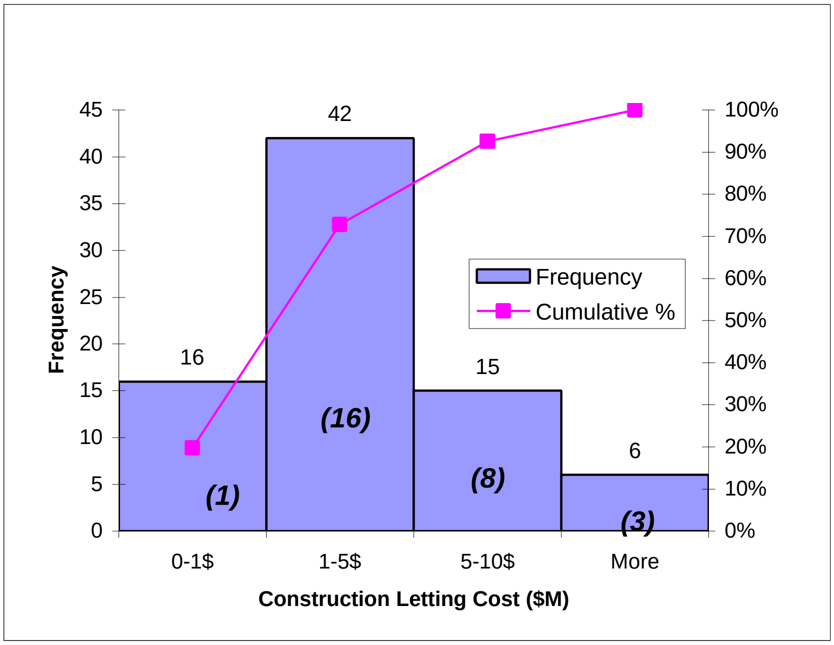

Figure 3
Frequency of construction letting cost

Figure 3 shows a distribution of the estimated letting cost. Most of the 75 projects are between 1-5 million. Again, the sample sizes of the projects selected for analysis in this study are shown in parentheses in the diagram. The sample has a similar distribution of letting cost to the population.

Figure 4 shows the distribution of the engineering design cost. As can be seen, most of the projects have design costs between $ 100,000 and 500,000. The sample size in each design cost category displays a similar distribution to the population.

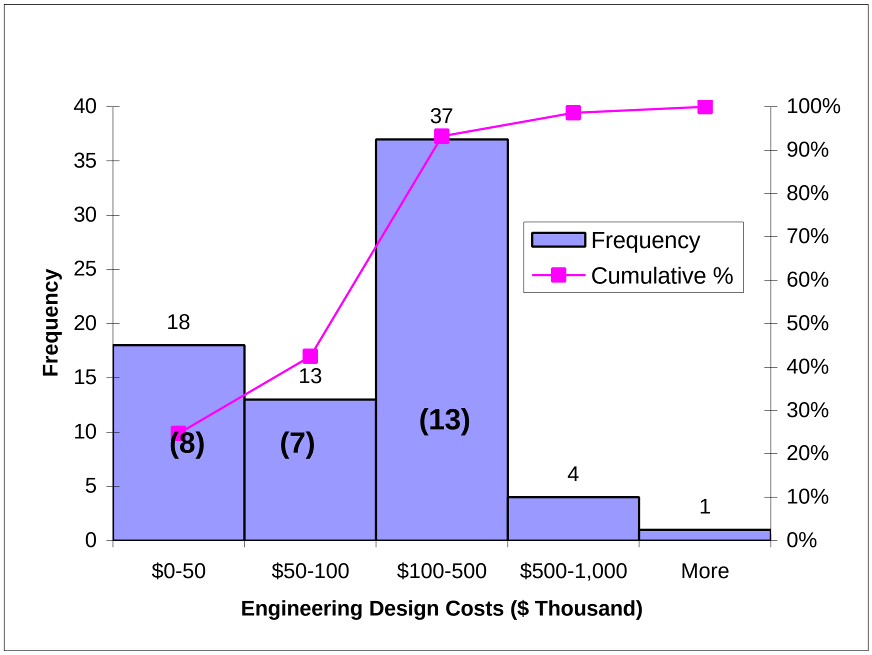

Figure 4
Frequency of engineering design costs

Methodology Applied in this Study

The ratio of engineering cost over construction cost, used by many studies presented in the literature, was found to be a highly variable value. This made it less useful as a measure of the relative cost of in-house and consultant design costs. While the ratio of design cost over construction cost takes into account the influence that project size has on design cost, it is unable to appropriately capture the impact of other factors that do not necessarily affect construction costs such as the number of plan changes, unique environmental conditions in which the facility is to be constructed and even design complexity. A measure which is capable of taking these additional factors into account is the ratio of design costs by in-house staff divided by the design cost by consultants. When applied in this study, this ratio was found to be more stable than the previous one and appeared to be an effective measure of relative design costs. Subsequently, it was used in the remainder of the study.

DOTD uses two types of projects: lump sum and cost plus. Both types of contracts may or may not be negotiated with consultants. Most of the contracts are lump sum with some negotiation. For these contracts, the contract price for an engineering design is determined by separate formulae for bridge and road designs. These formulae have been established and updated over a period of time. The formulae use estimates of the number of plan sheets and estimated hours of professional staff to perform the tasks to estimate the total man-hours. The man-hour estimates for the plan sheets are based on an assessment of the hours in-house staff would need to complete the sheets. Total labor cost is determined by multiplying the appropriate labor rate and man-hours.

Total costs are determined by adding labor costs and overhead, applying a profit factor, and adding direct costs. The final contract price usually is established with minor negotiation and modification.

Table 13 presents a typical example of the estimation of consultant design costs using the formula. The escalation rate of 3.3 percent per annum is the average escalation rate used among consultants in recent years for multi-year contracts. It is obvious that the process can be equally applied to estimate the design cost of in-house design projects if appropriate rates and other cost items are applied.

Table 13
Example consultant fee computation

Draftsman	745	Manhours x	$ 12.01	=	$ 8,947
Technician	1581	Manhours x	17.97	=	28,410
Pre-Professional	655	Manhours x	16.75	=	10,971
Engineer	1318	Manhours x	27.20	=	35,849
Supervisor	372	Manhours x	34.22	=	12,729
Principle	34	Manhours x	41.24	=	1,402
Direct Payroll Cost					98,310
Overhead	141%				138,716
Subtotal					237,027
Subtotal escalated by	1.033				244,849
Profit	15.120%				37,021
Direct Expenses					2,765
Total Fee					$284,635

Note: actual rates vary with contract.

The methodology employed in this study involved three alternative approaches of estimating in-house and consultant design costs. These are shown in Figures 5, 6, and 7.

In the first approach shown in Figure 5, only projects designed in-house in the past are considered. The in-house design costs are determined from accounting records of design time multiplied by in-house labor and overhead rates. Estimates of the consultant design costs of the same projects are determined by using the formulae to estimate consultant design hours and then applying consultant labor and overhead rates. Comparisons then are made between the estimates of the in-house and consultant design costs of each project.

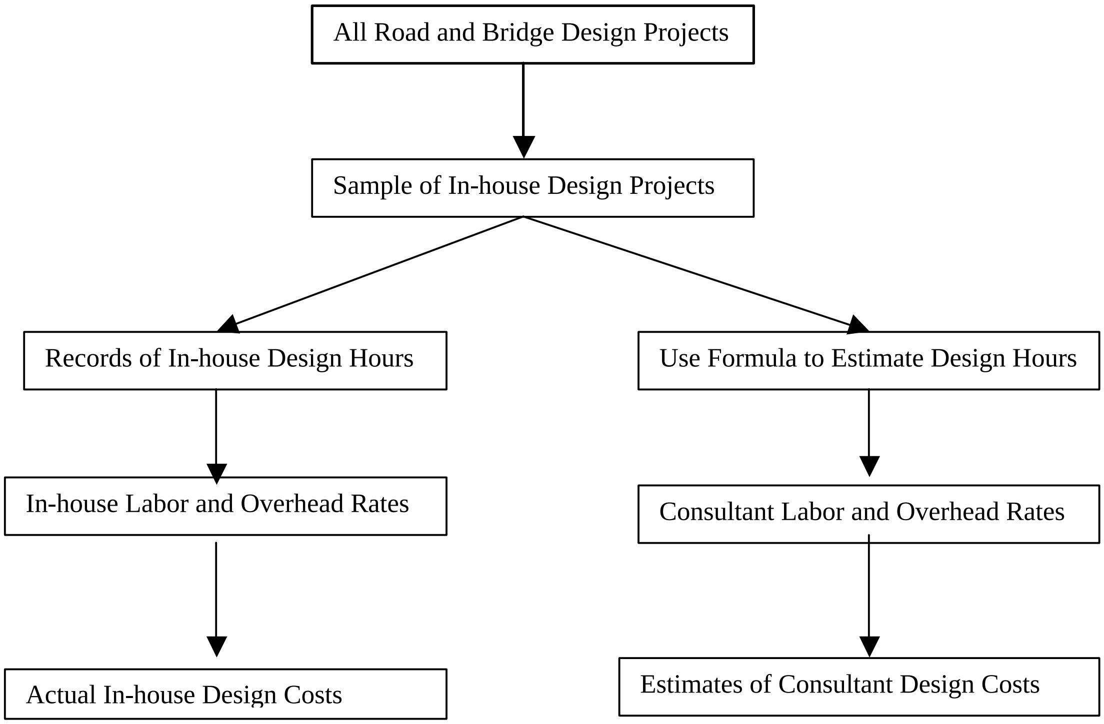

Figure 5
Methodology of approach 1

The design hours used in Approach 1 may be questioned on two counts. First, it is generally acknowledged by in-house staff that the record of in-house time may not be accurate. However, if there is a consistent bias to either under-report or over-report design time, the method used to incorporate "non-project" related time within the overhead (see Section 5.2), will cause the overhead rate to be either inflated or deflated to compensate for the effect. Thus, while in-house recorded hours may be inaccurate, in-house estimated design costs should be accurate.

The second concern with the methodology of Approach 1 is more serious since there is no way in which it can be controlled. The concern centers on the fact that consultant design hours had to be specially estimated for these projects by in-house staff, and there is no guarantee that the design hours estimated were not consciously or unconsciously deflated to put in-house design times in a more favorable light. For this reason, the results of Approach 1 cannot be considered in isolation, and Approaches 2 and 3 were compiled to eliminate any bias introduced with Approach 1.

Approach 2 is described in Figure 6. In this approach, all the projects in the sample that were designed by consultants in the past are considered. However, contrary to Approach 1, the same design hours are used to estimate both in-house and consultant design costs. The design hours were extracted from the records of awarded consultant design contracts.

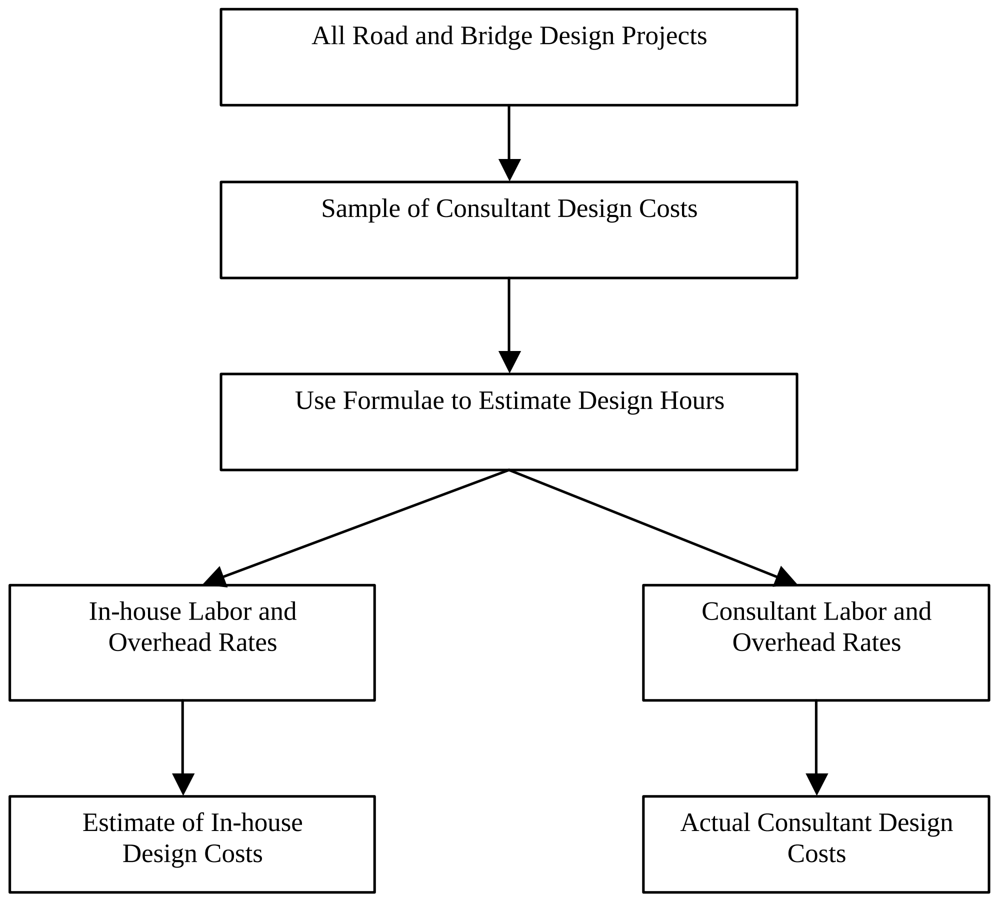

Figure 6
Methodology of approach 2

In Approach 2, the possibility of a bias in the estimate of design hours is combated, but the assumption of equal design hours among in-house and consultant design staff raises a new issue. Is it a valid assumption? Conceivably, a difference may exist, but short of having accurate records of in-house design time, there is no way of establishing this with available data. Thus, Approach 2, in addressing the uncertainty of the difference in design hours between in-house and consultant staff in Approach 1 raises new uncertainties about the assumption that design hours are the same. However, considering the results from other approaches simultaneously may reveal certain trends that indicate true values.

Approach 3 was developed to not depend on simulated project comparisons. Rather, for consultant projects it considers the average mix of staff used on 35 randomly selected consultant projects and applies labor and overhead rates to determine the average cost of one design hour. For in-house projects, the recorded total cost and total time for 20 randomly selected projects is used together with overhead costs to estimate the average cost of one in-house design hour. The method is illustrated in Figure 7.

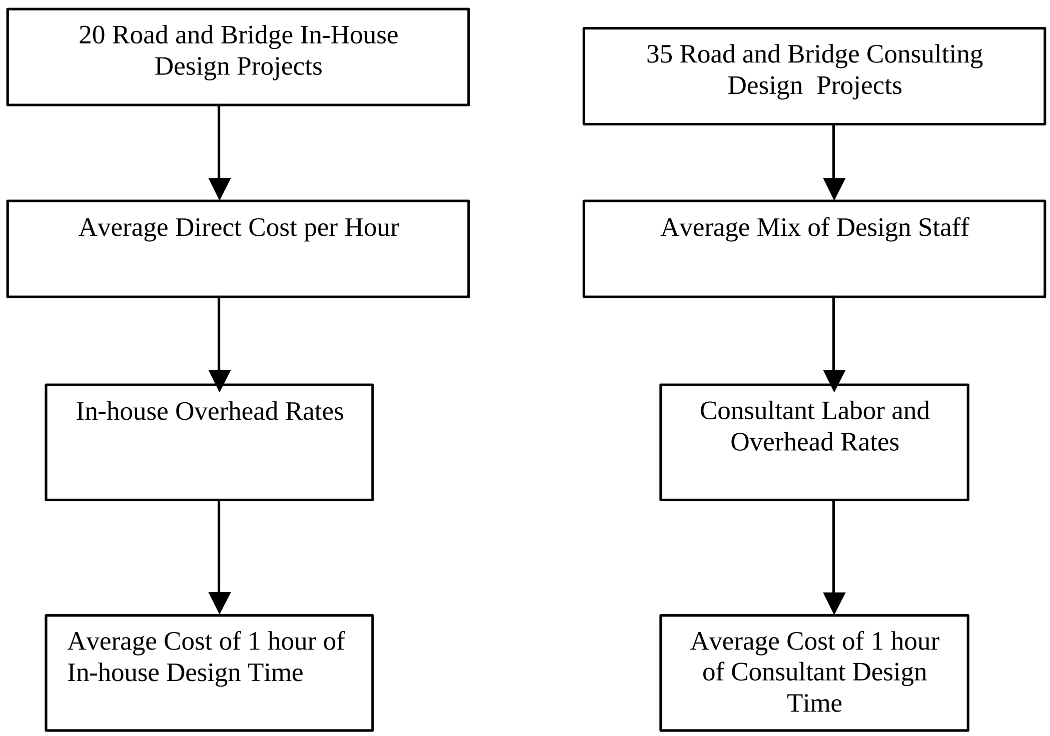

Figure 7
Methodology for approach 3

Approach 3 gives a third perspective of the comparative costs of in-house and consultant designs. It addresses some of the shortcomings of the other two approaches. Considering the results of Approaches 1, 2, and 3 together should provide the basis for a good interpretation of the data.

Description of Project Samples

From the list of projects in Table 12, a sample of 20 preliminary or final designs from 14 in-house projects and 17 preliminary and/or final designs from nine consulting projects were selected. Although the samples were not taken completely randomly, they closely resemble the 73 projects with respect to bid estimate, engineering cost, and ratio of engineering cost to consultant cost. In addition to these criteria, the samples were also chosen to represent types of projects such as river crossings, railroad overpasses, two-lane rural roads, intersections and four-lane rural roads. Only projects designed within the last five years were considered to avoid extensive adjustments of costs for time elapsed. Table 14 gives a description of the 20 in-house projects, whereas Table 15 presents the sample of nine consulting projects representing 17 designs.

Table 14
Sample of in-house projects

Project Type	SP Constr.	Description	Roadway	Bridge	Letting	Prelim Plans	Final Plans
Large River Crossings	033-03-0033	Red River Bridge @ Moncla (Main Spans)	N/A	In-House	Mar-96		X
	033-03-0032	Red River Bridge @ Moncla (Approaches)	Consultant	In-House	Feb-98		X
Medium River Crossings	047-02-0022	Boque Chitto River Bridge & Approaches	In-House	In-House	Nov-94		X
	260-05-0020	Tickfaw River Bridge	In-House	In-House	Jun-97		X
Small Water-way Crossings	378-03-0006	Whiskey Chitto River Bridge & Approaches	Consultant	In-House	Jul-97		X
	008-02-0025	Bayou Cholpe Bridge	In-House	In-House	Dec-94		X
Railroad Overpass	005-01-0056	Southern Pac. Railroad Overpass (Wyandotte)	Consultant	In-House	Dec-94		X
	003-10-0011	Southern Pacific Railroad Overpass	Consultant	In-House	Feb-98		X
2-Lane (Rural)	039-03-0011	Manifest - East	In-House	Consultant	Nov-93	X	
	039-03-0014	Junction La 126 – Harrisonburg	In-House	Consultant	May-95		X
	829-31-0001	Coulon Plantation Rd. La 308 – 40 Arpent Rd.	In-House	N/A	Jan-95	X	
	829-31-0001	Coulon Plantation Rd. La 308 - 40 Arpent Rd.	In-House	N/A	Jan-95		X
4-Lane (Rural)	829-26-0005	Golden Meadow – LaRose	In-House	N/A	Nov-97	X	
4-Lane (Rural)	829-26-0005	Golden Meadow – LaRose	In-House	N/A	Nov-97		X
5-Lane (Urban)	268-01-0012	I-12 to Dumpling Creek	In-House	In-House	Dec-97		X
5-Lane (Urban)	268-01-0012	I-12 to Dumpling Creek	In-House	In-House	Dec-97		X
Intersection Improvements	260-01-0016	La 42 @ La 44	In-House	N/A	Oct-97	X	
Intersection Improvements	260-01-0016	La 42 @ La 44	In-House	N/A	Oct-97		X
Interstate Rehabilitation	450-91-0077	Calcasieu River Bridge - Kayouchee Coulee	In-House		Dec-97	X	
Interstate Rehabilitation	450-91-0077	Calcasieu River Bridge - Kayouchee Coulee	In-House		Dec-97		X

Table 15
Sample of consultant projects

Project Type	SP Eng.	SP Constr.	Roadway	Bridge	Prelim. plans	Final plans	Contract
Big Creek and Cypress Creek Bridges	700-10-0023	133-02-0030	Consulting	Consulting	X	X	1992
Dodson Sikes	700-23-0072	091-07-0014	Consulting	Consulting	X	X	1991
Bayou Boeuf	700-29-0066	417-02-0023	Consulting	N/A	X	X	1991-1994
Bayou Mallet Bridge and Approaches	700-25-0029	211-03-0004	Consulting	In-House	X	X	1993-1995
Winnfield Natchitoches Parish Line	700-22-0003	022-02-0028	Consulting	N/A		X	1993
JCT.171 – JCT. 175	700-24-0008	843-01-0010	Consulting	Consulting	X	X	1991
Toro Creek Bridge	700-24-0029	117-01-0018	Consulting	Consulting	X	X	1992
Big Creek and Cypress Creek Bridges	700-22-0017	321-01-0013	Consulting	Consulting	X	X	1992
Siegen Lane Improvements	700-25-0020	817-40-0001	Consulting	Consulting	X	X	1992

ANALYSIS

Analysis of Overhead Cost

The size, scope of activities, and organizational structure of DOTD cause different types of overhead costs to occur throughout the organization. Some overhead costs are easier than others to trace to road and bridge projects. Engineering supervision within the Bridge Design Section, for example, can be closely identified with the design projects within that section. Several alternative methods are acceptable to allocate supervision of this nature. One might allocate the costs on the basis of the number of projects, the number of staff supervised, the cost of each project, total section costs, total payroll, or total payroll charged directly to projects.

In large organizations, like DOTD, some overhead costs are incurred in sections besides the one where the project originates. There are levels of management that oversee several sections directly involved with various engineering and design services. Their costs require allocation to each section overseen and to those projects within those sections. Likewise, support services like payroll, purchasing, information systems, safety, legal, and insurance must be allocated though they are also difficult to trace directly to individual projects. Since support services are difficult to trace to specific projects, various procedures are required to allocate these costs across the organization and, ultimately, to specific road and bridge projects.

The problem of identifying and allocating overhead costs to individual products is well known within the manufacturing sector. Overhead costs are commonly perceived as fixed and uncontrollable costs. Large enterprises, however, have found overhead costs to be among the fastest growing costs. As manufacturers grew and diversified, therefore, understanding the relationship between overhead costs and total product costs became essential to survival. The corollary to DOTD is apparent. With multiple services and a large organizational size, DOTD has more in common with large manufacturers than small consulting engineering firms. Hence, like the manufacturer, DOTD overhead costs need to be identified throughout the organization and allocated in some manner to individual products and services.

DOTD Overhead Rates

To generate the total cost of design projects, DOTD overhead is calculated at several levels of the organization and allocated step-by-step to finally reach the individual sections that work directly on the project. The next several sections explain this step-by-step process. Step 1 is to determine the DOTD-wide support services overhead and to assign this to each section in the department. Step 2 is to identify upper management supervision within the Directorate of Engineering and Program and Project Development and assign the cost to each section that it supervises. Step 3 is to determine supervision, clerical, and other indirect charges incurred in each section and add this to the cost estimates of the previous two steps to form actual indirect cost estimates for each section. An overhead rate is established by dividing total indirect costs for each section by the direct costs of that section. The end result is a single composite overhead rate for each section working directly on design projects that incorporates DOTD-wide support services, upper level management, and the section's own indirect costs.

Step 1: DOTD-wide Support Services Overhead Rate. Support services overhead includes insurance, payroll, purchasing, data processing, legal, utilities, and so on. Most of these services are provided by sections under the Management and Finance Directorate (Section 10) and under the administration of the Secretary of DOTD (Section 1).

All sections in DOTD are designated as either "direct" or "indirect" to indicate whether they are directly or indirectly involved with the supervision or administration of design services. Only indirect sections contribute toward the estimation of a departmental-wide support service overhead rate, the supervision or administration of the direct section being included in those sections themselves. The sections identified as providing indirect support services and their fiscal year 1996 costs are shown in Table 16.

Table 16
DOTD support services and insurance costs, 1995-96

Section	Section Name	1995-96 Expenditures
1	Office of the Secretary	$466,380
6	Project Control	884,206
9	Fleet Management	176,326
10	Director of Administration	264,525
13	Data Processing	3,059,829
14	Purchasing	429,930
15	Financial Services	2,430,901
16	Personnel	746,200
17	Insurance and Misc. Costs	11,380,395
26	Building Services	3,626,097
31	Audit & Evaluation	674,988
32	Central Warehouse	69,360
33	LTRC-Training	1,847,991
37	Compliance Programs	492,185
38	Budget & Management Control	315,330
46	Office of the Secretary	35,989
47	Legal	2,349,767
50	Safety	851,386
60	SRA: Administration & Wages	3,437,963
75	Insurance and Misc. Costs	58,620,447
83	Office of the Secretary	190,614
--	Occupancy Rent	3,062,023
Total Support Services & Insurance Costs		$95,412,832

Risk management insurance is 61 percent of total support service costs in fiscal year 1995-96. This insurance represents DOTD's share of the state of Louisiana's self-insurance program as assigned to each state agency by the Office of Risk Management. For reasons explained later in this chapter, some of these self-insurance costs are excluded to calculate a revised support services rate that is more consistent with consultant rates. Total direct and indirect costs for 1995-96 were $337,502,270, of which total direct costs were $242,089,438. Total direct and indirect costs for 1996-97 were $326,232,886, of which total direct costs were $238,469,830. Support services expressed as percentages of direct costs and total costs for fiscal years 1995-96 and 1996-97 are displayed in Tables 17 and 18.

Table 17
Indirect support services costs, 1995-96

Description	**Compared to Direct Costs**		**Compared to Total Costs**	
	Amount	**%**	**Amount**	**%**
Risk Management Costs	$58,620,447	24.21%	$58,620,447	17.37%
Other Support Service Costs	36,792,385	15.20%	36,792,385	10.90%
Total Support Service Costs	95,412,832	39.41%	95,412,832	28.27%
Total Direct Costs	$242,089,438			
Total Costs			$337,502,270	

Table 18
Indirect support services costs, 1996-97

Description	**Compared to Direct Costs**		**Compared to Total Cost**	
	Amount	%	Amount	%
Risk Management Costs	$50,165,449	21.03%	$50,165,449	15.38%
Other Support Services Costs	37,597,608	15.77%	37,597,608	11.52%
Total Support Services Costs	87,763,056	36.80%	87,763,056	26.90%
Total Direct Costs	$238,469,830			
Total Costs			$326,232,886	

State self-insurance costs account for 15.38 percent of total costs in 1996-97 and 17.37 percent in 1995-96. About 10 percent to 15 percent of total costs pertain to other support service costs. The total support services overhead rate is determined as described below.

1) Support Services Overhead Rate.

Support Services Overhead Rate = Total Support Services Costs/Total Direct Costs
According to DOTD Audit Advisory Memorandum No. 980072 dated February 19, 1998, the rate for the year ended June 30, 1997, was 17.09 percent. The rate was determined as follows:

Support Services Overhead Rate = $33,578,841/$196,441,105 = 17.09%

The allocation of support services proceeds in two steps as follows: (1) determine the total cost of each direct section, and (2) add 17.09 percent of that cost. Naturally, the greater the cost incurred in a direct section, the greater the share of support services allocated to that section. Sections incurring construction and maintenance costs, for example, are allocated greater dollar amounts of support service costs than engineering design sections. The percentage allocated is constant, however.

This analysis of DOTD support services overhead departs from the approach used by the audit division in two regards. First, we classify risk management insurance as an indirect cost. Second, actual fringe benefit costs are included. These adjustments are necessary to ensure that all in-house costs are included in the process of determining full cost of each in-house engineering design project included in the study. DOTD, in its analysis of in-house overhead, requires a support services rate for federal grant purposes that excludes, per federal mandate, insurance and employee fringe benefits. Hence, federal fund requests itemize insurance, employee benefits, and other support services separate from one another. Viewed in this manner, our blended support services rate (which includes both insurance and employee fringe benefits) should not be viewed as conflicting with the rate determined by the audit division.

2) Revised Support Services Overhead Rate

Because DOTD's risk management insurance is more comprehensive than consultant business insurance, an estimate was made of what would constitute an equitable in-house insurance cost. Using information from 112 audits of consulting engineering firms over the period 1993 through 1997, the average cost of business insurance incurred by consultant engineering firms was found to be 5 percent of total consultant costs. This is less than one-third of DOTD's fiscal year 1997 rate of 15.38 percent.

The types of insurance for which DOTD is self-insured are as follows (percent of total 1995-96 costs):

- Auto Insurance (6%)
- Workman's Compensation (15%)
- General Comprehensive Liability (3%)
- Fire Insurance (1%)
- Road, Bridge, Dam & Tunnel Coverage & Tort Insurance (63%)
- Insurance Administrative Costs (12%)

The largest category of insurance, road, bridge, dam & tunnel coverage & tort insurance, is 63 percent of the total insurance. This coverage is described as follows in written documentation provided by the Budget and Financial Services Office of DOTD (Section 15 and 38):

"this policy of insurance provides for payment of damages resulting from the establishment, design, construction, existence, ownership, maintenance, use, extension, improvement, repair, or regulation of any state bridge, tunnel, dam, street, road, highway, or expressway. "

This broad description also is consistent with DOTD management's perception that risk management insurance is not strictly comparable to typical business insurance incurred by consultant engineering firms. Omitting this category of insurance, the remaining risk management insurance is about 4.6 percent of total DOTD costs. Although this rate appears similar to the average consultant rate of 5 percent, it is actually still much larger since the consultant rate excludes construction costs from total costs while the in-house rate includes these costs. If construction costs were included the average consultant insurance cost would decline significantly. Nevertheless, only the "road, bridge, dam and tunnel coverage and tort insurance" portion of risk management insurance costs were omitted in the overhead calculations that follow. The revised support services rate as a percentage of total direct costs are 24.06 percent for 1996-97 and 23.46 percent for 1995-96. The revised rate is used in this study.

Table 19
Revised indirect services support rate, 1996-97

Description	**Compared to Direct Costs**		**Compared to Total Costs**	
	Amount	**%**	**Amount**	**%**
Risk Management Costs	$19,768,080	8.29%	$19,768,080	6.68%
Other Support Service Costs	37,597,608	15.77%	37,597,608	12.71%
Total Support Service Costs	57,365,688	24.06%	57,365,688	19.39%
Total Direct Costs	$238,469,830			
Total Costs			$295,835,518	

Table 20
Revised indirect services support rate, 1995-96

Description	**Compared to Direct Costs**		**Compared to Total Costs**	
	Amount	**%**	**Amount**	**%**
Risk Management Costs	$20,012,999	8.27%	$20,012,999	6.70%
Other Support Service Costs	36,792,385	15.20%	36,792,385	12.31%
Total Support Service Costs	56,805,384	23.46%	56,805,384	19.01%
Total Direct Costs	$242,089,438			
Total Costs			$298,894,822	

Step 2: Upper Management Supervision Rate. The Engineering and Program and Project Development Directorate of DOTD has three management levels for the purpose of this study. The highest level, Section 20, includes the director and two assistant directors (one of these positions is currently vacant). In the second management level, consisting of Sections 80 and 82, there are two employees in each of the sections. The third management level occurs within each section performing the bulk of the engineering work directly chargeable to projects. The sections and their staff size are summarized in Table 21.

Table 21
Active staff sizes of selected engineering sections as of September, 1997

Section	**Description**	**Staff Size**
Upper Management Level:		
20	Chief Engineer (Director and Assistant Director)	2
Second Management Level:		
80	Design Support	2
82	Engineering & Design Support	2
Third Management Level:		
11	Highway Needs	7
18	Consultant Contract Services	10
24	Road Design	57
25	Bridge Design	57
27	Geometrics	7
28	Environmental Section	16
29	Hydraulics	12
30	Location and Survey	76
39	Contracts and Specifications	21
67	Pavement and Geothermal design	11
68	Water Resources Design	10
81	Public Transport	10
88	Aviation Program	12
	Total for Third Management Level	306

Section 20 costs are allocated to all sections under its supervision using the following two-step procedure: (1) total cost for section 20 are first estimated by adding support services costs using the indirect support services overhead rate of section 20 and (2) they are then distributed to subordinate sections based on their payrolls. Section 20 expenditures for fiscal year 1995-1996 were $366,611 and $452,654 after the adjustment for support services. The following table demonstrates this process for fiscal year 1995-1996.

Table 22
Allocation of upper management level costs in Section 20
(Based on Percent of Payroll Expenditures)

Section	Payroll	% of Total Payroll	Allocation of Section 20 Costs
11	$357,447	2.87%	$12,995
18	279,897	2.25%	10,175
24	2,141,925	17.20%	77,868
25	2,347,366	18.85%	85,337
27	267,253	2.15%	9,716
28	501,011	4.02%	18,214
29	467,652	3.76%	17,001
30	3,052,512	24.52%	110,972
39	903,431	7.26%	32,844
67	397,116	3.19%	14,437
68	569,056	4.57%	20,688
80	121,704	0.98%	4,424
81	363,949	2.92%	13,231
82	235,083	1.89%	8,546
88	445,731	3.58%	16,204
Total	$12,451,133	100.00%	$452,654

On average, this allocation represents slightly more than a 2 percent increase to each section. Subsequent to allocating Section 20 to all subordinate sections, total costs in each section are shown in the following table:

Section 80 and Section 82 are also supervisory management sections. Section 80, Design Support, supervises activities in Sections 27 (Geometric Design), 29 (Hydraulics), 67 (Pavement and Geotechnical Design) and 68 (Water Resources). Section 82, Engineering and Design Support, supervises Sections 28 (Environmental), 30 (Location and Survey), and 39 (Contracts and Specifications). Both Sections 80 and 82 have two active staff members--a senior level engineer and an administrative secretary. Like Section 20, the costs of Sections 80 and 82 are allocated to the sections they oversee based on payroll expenditures. The table that follows reveals total costs in each section following distribution of Sections 80 and 82. The total costs per section in the table include support services and all upper management level (i.e., Sections 20, 80, and 82).

Table 23
Adjusted engineering design section expenditures, 1995-96

Section	Section Costs	Insurance	Support Services	Supervision (Section 20)	Total
11	$368,406	$30,467	$55,998	$12,995	$467,866
18	308,207	25,489	46,847	10,175	390,718
24	2,175,972	179,953	330,748	77,869	2,764,542
25	2,376,360	196,525	361,207	85,337	3,019,429
27	276,129	22,836	41,972	9,716	350,653
28	540,496	44,699	82,155	18,214	685,564
29	498,480	41,224	75,769	17,001	632,474
30	3,818,149	315,761	580,359	110,972	4,825,241
39	937,977	77,571	142,572	32,844	1,190,964
67	468,908	38,779	71,274	14,437	593,398
68	576,014	47,636	87,554	20,688	731,892
80	122,051	10,094	18,552	4,424	155,121
81	5,118,337	423,286	777,987	13,231	6,332,841
82	238,104	19,691	36,192	8,546	302,533
88	3,977,846	328,968	604,633	16,204	4,927,651
Total	$21,801,436	$1,802,979	$3,313,819	$452,653	$27,370,887

Table 24
Allocation of second management level supervision, 1995-96

Section	Table 23 Total	Allocate Section 80	Allocate Section 82	Total
11	$467,866			$467,866
18	390,718			390,718
24	2,764,542			2,764,542
25	3,019,429			3,019,429
27	350,653	$24,371		375,024
28	685,564		$34,008	719,572
29	632,474	42,645		675,119
30	4,825,241		207,201	5,032,442
39	1,190,964		61,324	1,252,288
67	593,398	36,213		629,611
68	731,892	51,892		783,784
80	155,121	(155,121)		0
81	6,332,841			6,332,841
82	302,533		(302,533)	0
88	4,927,651			4,927,651
Total	$27,370,887	0	0	$27,370,887

Step 3: Section Overhead Rates. The third step in determining engineering design cost overhead occurs at the section level where the design work is performed. The primary sections of interest are Sections 18 (Consultant Contract Services), 24 (Road Design), and 25 (Bridge Design). In each of these sections, costs are grouped according to whether they are (1) charged to projects or (2) noncharged costs. For this study, noncharged section costs include support services and upper management level costs allocated to each section in the previous Steps 1 and 2. Section overhead rates are expressed as total noncharged costs divided by charged project costs. The following tables shows the overhead computation for Sections 18, 24 and 25 for 1995-96.

Table 25
Overhead rate for Section 18, 1995-96

Description	Amount
Section Non-Project Charges	$217,056
Applied Overhead:	
Supervision: Section 20	10,175
Insurance	25,489
Other Support Services	46,847
Total Non-Project Charges & Overhead	299,567
Divided by Project Charges	$91,151
Section Blended Overhead Rate	329%

Table 26
Overhead rate for Section 24, 1995-96

Description	Amount
Section Non-Project Charges	$1,210,774
Applied Overhead:	
Supervision: Section 20	77,869
Insurance	179,953
Other Support Services	330,748
Total Non-Project Charges & Overhead	1,799,344
Divided by Project Charges	$965,198
Section Blended Overhead Rate	186 %

Table 27
Overhead rates for Section 25, 1995-96

Description	Amounts
Section Non-Project Charges	$1,408,574
Applied Overhead:	
Supervision: Section 20	85,337
Insurance	196,525
Other Support Services	361,207
Total Non-Project Charges & Overhead	2,051,643
Divided by Project Charges	$967,786
Section Blended Overhead Rate	212%

Consultant Overhead Rates

DOTD conducts audits of consultant records as part of DOTD's oversight of consultant contracts. From these audits, average overhead rates are determined. The average overhead rate serves as an estimate, or benchmark, for contracting with consultants. For the 1997-98 fiscal year, the benchmark consultant overhead rate was 153.77 percent of total direct labor charges.

The study team reviewed 104 DOTD audits of consultant overhead. Table 28 summarizes the sample of overhead audits reviewed. The bottom two lines in Table 28 present different average overhead rates. The bottom row is the simple mean average overhead rate calculated by summing the individual consultant rates and dividing by the number of rates. For fiscal year 1995-96, the average rate for the 37 consultants audited by DOTD was 158 percent. The second average rate shown in the line above the "average consultant rate" is based on average costs for each cost item. This is a weighted average calculated by dividing the average total indirect costs by the average direct costs. For fiscal year 1995-96 audits, this rate was 150.74 percent. The consultant overhead rates shown are consistent with the 1997-98 benchmark rate of 153.77 percent established by DOTD.

Standard contracts with consultants include provisions that increase the consultant overhead rate, and one of these provisions includes a profit factor. Moreover, the departmental supervision of the consultant contract also serves to increase the effective overhead rate on consultant projects. The factors for DOTD supervision for the Road and Bridge Sections are obtained in Section 6.1 of this report and are 15 percent and 25 percent, respectively. Table 29 illustrates how these additional factors affect the consultant overhead rate for 1995-96.

Table 28
Average consultant overhead, 1993-96

Item	Average	Average	Average	Average	% of Direct Labor Costs
	FY93-94	FY94-95	FY95-96	FY93-96	FY93-96
Number of Consultants	41	26	37	104	
Direct Labor Costs	$453,954.24	$625,875.57	$608,050.08	$562,626.63	100.00%
Indirect Costs:					
Indirect salaries	262,973.30	356,542.50	392,172.84	337,229.55	59.94%
Bonuses	10,101.99	44,355.24	35,229.64	29,895.62	5.31%
Insurance- Employee	38,618.49	53,576.52	57,089.38	49,761.46	8.84%
Payroll Taxes	58,162.31	81,199.10	80,261.71	73,207.71	13.01%
Pensions Plan/Profit Sharing	15,177.10	24,669.86	24,363.50	21,403.49	3.80%
Advertising	420.59	288.13	615.22	441.31	0.08%
Aircraft Expenses	91.53	0.00	0.00	30.51	0.01%
Auto Expenses	10,864.89	11,943.43	14,094.32	12,300.88	2.19%
Business Development	43.21	0.00	0.00	14.40	0.00%
Casual/Contract Labor	720.94	268.26	31.78	340.33	0.06%
Computer Expenses	1,959.05	1,035.37	7,429.46	3,474.63	0.62%
Continuing Education	1,641.37	4,726.95	6,034.77	4,134.36	0.73%
Depreciation	37,633.75	52,794.56	45,862.52	45,430.28	8.07%
Dues & Subscriptions	4,977.10	7,763.56	6,825.92	6,522.19	1.16%
Employee Morale	2,074.61	5,367.44	2,444.71	3,295.59	0.59%
Insurance—Business	56,827.86	84,458.12	66,775.72	69,353.90	12.33%
Miscellaneous	1,479.68	3,877.08	3,050.27	2,802.35	0.50%
Pre-Contract Expense	918.86	796.41	1,269.59	994.95	0.18%
Professional Services	17,550.01	22,245.15	24,199.76	21,331.64	3.79%
Rent—Building	20,501.09	44,960.52	37,308.86	34,256.82	6.09%
Rent—Equipment	4,414.33	6,313.11	6,760.96	5,829.47	1.04%
Repair & Maintenance	12,612.91	16,201.81	16,670.60	15,161.77	2.69%
Supplies --Engineering & Drafting	440.98	0.00	473.57	304.85	0.05%
Supplies & Office Expenses	26,077.40	40,981.37	46,390.36	37,816.38	6.72%
Taxes/Licenses/Fees	6,336.61	8,465.95	7,251.45	7,351.34	1.31%
Telephone	11,546.71	15,707.82	16,954.75	14,736.43	2.62%
Travel	5,002.54	12,847.28	12,387.53	10,079.12	1.79%
Utilities	7,482.97	6,603.71	6,920.96	7,002.55	1.24%
Postage	212.92	0.00	0.00	70.97	0.01%
Marketing	75.82	0.00	0.00	25.27	0.00%
Business Meals	1.32	300.27	332.10	211.23	0.04%
Business	392.03	0.00	0.00	130.68	0.02%

Item	Average	Average	Average	Average	% of Direct Labor Costs
	FY93-94	FY94-95	FY95-96	FY93-96	FY93-96
Development/Promotion					
Corporate Allocation	2,594.27	2,185.56	3,195.59	2,658.47	0.47%
Directors Fees	136.59	0.00	0.00	45.53	0.01%
Recruiting	168.29	0.00	0.00	56.10	0.01%
New Business	56.82	0.00	0.00	18.94	0.00%
Meeting Conventions	178.01	306.25	126.34	203.53	0.04%
Management Services	4,578.07	5,787.09	-5,978.36	1,462.27	0.26%
Total Indirect Costs	$625,046.35	$916,568.43	$916,545.81	$819,386.86	145.64%
Overhead Rate (average costs)	137.69%	146.45%	150.74%	145.64%	
Average Consultant OH Rate	142.86%	153.92%	158.00%	151.59%	

Table 29
Effective consultant overhead rates, 1995-96

Description	Bridge Projects	Road Projects
Average Consultant Overhead Rate for 1995-96	158%	158%
Net Effect of Other Factors on Overhead:		
13% Profit Factor	34%	34%
DOTD Supervision: 15% Road Section 25% Bridge Section	73%	44%
Effective Consultant Overhead Rates	265%	236%

Table 30 compares Sections 24 (Road Design) and 25 (Bridge Design) in-house overhead rates to average and effective consultant overhead rates.

Table 30
Comparison of overhead rates, 1995-96

Section	Overhead rates
Section 24 (Road design)	186%
Section 25 (Bridge design)	212%
Average Consultant Overhead Rate	158%
Effective Consultant Overhead Rate: Road Projects Bridge Projects	 236% 265%

Two factors contribute to in-house overhead rates being higher than the average consultant overhead rate. First, DOTD's fringe benefit rate is nearly 58 percent compared to around 33 percent for consultants. Second, DOTD has a lower percent of labor time charged to projects. Consultants average 63 percent of labor costs charged to projects, while Sections 24 and 25 were substantially lower at 52 percent and 48 percent, respectively (See Table 3.).

Salary Rate Comparisons

Although DOTD has higher fringe benefit rates, the base salary rates are lower than those of consultants. This is demonstrated in the table 31.

Table 31
Comparison of base salary rates, 1995-96

Position Description	Average Hourly In-house Base Salary Rate	Average Hourly Consultant Base Salary Rate	% Consultant/In-house Hourly Rate over/(under)
Drafting	$10.55	$11.47	8.7%
Technician	12.64	15.45	22.2%
Pre-professional	13.94	16.35	17.3%
Engineer	22.32	26.14	17.1%
Supervisor	24.17	32.23	33.4%
Principal	34.53	40.18	16.4%

As shown in Table 32, salary rates with fringe benefits are nearly the same for three skill positions (pre-professional, engineer, and principal); higher for consultants in two areas (technician and supervisor); and higher for in-house at another area (drafting). This suggests that, overall, total in-house labor costs are very similar to those of consultants on an hourly basis.

Table 32
Comparison of salary rates with fringe benefits, 1995-96

Position Description	Average Hourly In-house Salary Rate with Benefits	Average Hourly Consultant Salary Rate with Benefits	% Consultant/In-house Hourly Rate over/(under)
Drafting	$16.61	$15.30	(7.9%)
Technician	19.90	20.61	3.6%
Pre-professional	21.94	21.81	(0.6%)
Engineer	35.13	34.87	(0.8%)
Supervisor	38.05	42.99	13.0%

Principal	54.35	53.60	(1.4%)

Analysis of Projects

To compare the cost of providing pre-construction engineering services by in-house staff or by consultants, two sets of project samples were analyzed using three separate analysis approaches. In each analysis, the costs of an actual sample of projects by one provider are compared with the estimated costs of the alternative provider. The following sections consider several cost features of the sampled projects. The additional costs incurred by DOTD in letting contracts to consultants are discussed. Costs related to the sample of in-house projects is discussed and analyzed. As applicable, the in-house and consultant overhead rates developed by in this study are applied in the analysis of projects. In the first analytical approach the actual in-house costs are compared with estimated costs as if the project had been offered to consultants. The second analysis compares the costs of the sample of consulting projects are to the estimated costs that would have occurred had the project been done in-house. The third analysis considers the average cost of one design hour for in-house and consultant staff. A summarization of the findings of the three approaches is included at the end of this section of the report.

Estimation of DOTD Costs for Contract Initiation and Consultant Supervision.

As with any outsourcing or subcontracting costs are incurred preparing a contract, supervising the project and maintaining accounting records. Initiation of consulting projects, which includes estimation of lump-sum fee, preparing the contract, reviewing the contract and negotiating the contracts, are identified in the accounting system by Function Code 58. Most of this work occurs in Section 18, while estimation of the fee is done in Sections 24 and 25 and may or may not be charged to Function Code 58. Supervision of consulting projects, which is done by Sections 24 and 25, is charged to Function Code 60. Other costs may include revision of completed plans (Function Code 56), maintaining contracts, accounting cost for handling invoices and payments, etc. While the initiation and supervision of consulting projects are clearly identifiable in the accounting system through their function code, the other cost associated with consulting projects are less clearly defined. For instance, Section 6 (contracts management) maintains the contracts as part of their service. Part of these costs is charged to the overhead. However, some of the cost should be charged directly to the projects.

The following analysis concentrates on Function Codes 58 and 60, the initiation and supervision of consulting projects, respectively. The true in-house cost for consultant may be slightly higher than these estimates. Two different estimates for these costs were obtained. One is based on the sample of consulting projects the other is based on the accounting database for the years 1992 to 1997. For the sample of consulting projects all in-house costs charged to projects with Function Codes 58 or 60 were summed up and divided by the total lump sum cost for consultant. This percentage serves as an estimate of in-house cost as percent of consultant project cost. These were done separately for Sections 18, 24, and 25. To determine whether or not the sample was a good estimate of the overall average man-hours used for consultants, the project charges in the accounting database were analyzed also.

Table 33
Consultant contract initiation and supervision

Project Number	Contract FC58		Supervision FC60	
	Sec.18&24	**Sec.18&25**	**Sec.24**	**Sec.25**
700-10-0023	1%	2%	1%	33%
700-23-0072	1%	2%	2%	12%
700-29-0066	3%		10%	
700-25-0029	8%		26%	
700-22-0003	11%		24%	
700-24-0008	5%	4%	0%	27%
700-24-0029	4%	12%	3%	11%
700-22-0017	8%	*26%*	4%	11%
700-25-0020	1%	10%	21%	*112%*
Average	5%	6%	10%	19%

The sample of nine consultant projects was adjusted for outliers (in italics). For the sample of consultant projects, the average in-house cost for preparing the contract was 5 percent of consultant cost for road design contracts and 6 percent of consultant cost for bridge design contracts. The supervision cost for consultant projects were 10 percent in the road section and 19 percent in the bridge section.

The following figures show the distribution of hours based on the accounting database for the budget years 1992 to 1997. Figure 8 shows the distribution of hours spent on preparing consulting contracts. The average number of man hours spent on the preparation of contracts is 48 hours which, when conducting the same analysis on the sample, also produces 48 hours as the average.

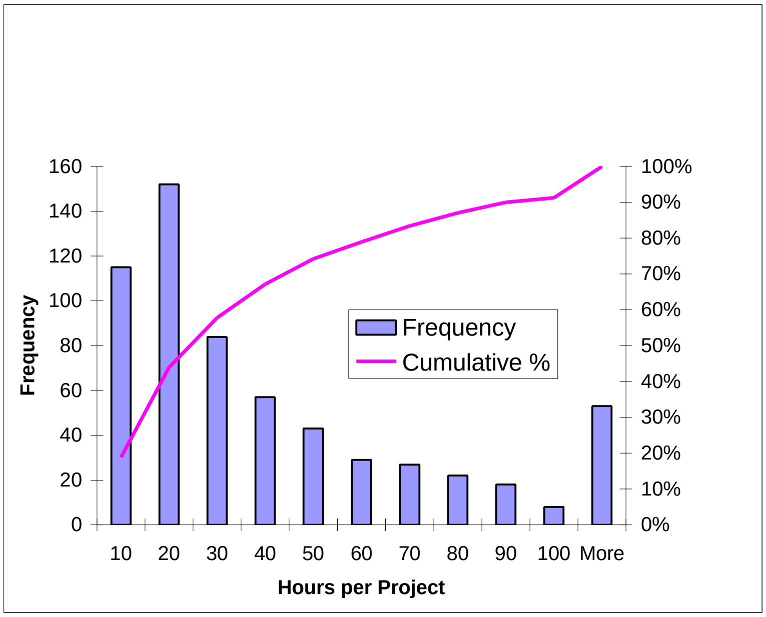

Figure 8
Frequency of hours spent on consultant contract preparation

Figure 9 shows the frequency of consultant supervision hours in Section 24 (road design). The average of the distribution is 130 hours. The average hours of supervision in the sample of road design projects is 143 – a value very close to the population value.

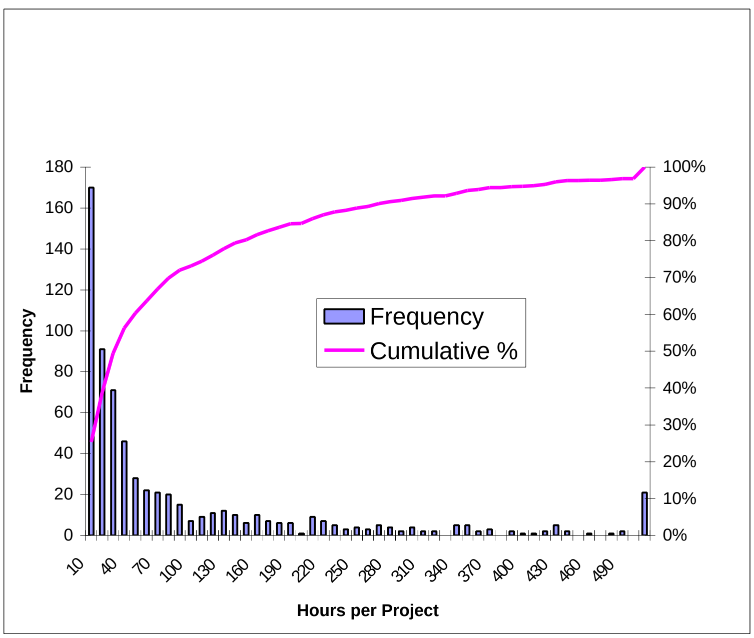

Figure 9
Frequency of consultant supervision hours per project in Section 24

Section 25 supervision hours are shown in Figure 10. The average is 151 hours per project. Reviewing the supervision hours of the sample projects in section 25 (bridge design) produces an average of 154 hours per project. Hence the review of accounting data for six years (1992-1997) shows a similar result to that obtained from the sample. Although the average number of hours spent on supervision of consulting projects is about the same in the road and bridge sections, the dollar amount as a percent of contract cost is larger in the bridge section because the bridge design contract amounts are smaller than for road designs. Thus, the in-house cost as a percent of consultant cost is much higher in the bridge section than in the road section.

The accounting database shows that the total in-house added cost to consultant projects, as derived from the contract initiation and supervision costs, are 15 percent of consultant cost for road designs and 25 percent for bridge designs. This can be derived from Table 33 by adding the percentages for contract initiation and supervision for each of the sections. An analysis of the man-hours charged to contract initiation (Function Code 58) and consultant supervision (Function Code 60) over the years 1992 to 1997 shows that these charges are fairly stable.

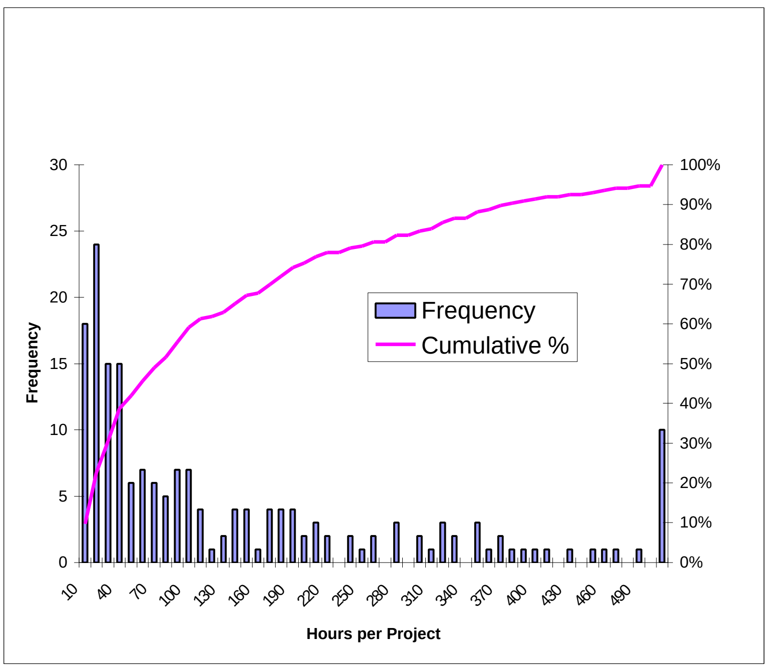

Figure 10
Frequency of consultant supervision hours per project in Section 25

Approach 1: Analysis of In-house Projects.

Actual costs for 20 designs from 14 in-house projects were compared to the costs that would have been paid to consultants had DOTD contracted out the engineering design. Five preliminary plans and fifteen final plans were included in the sample. The sample described in the methodology has three types of waterway crossings (large, medium, and small), two-lane and four-lane rural highways, a railroad overpass, intersection improvements, and interstate rehabilitation. Since two of the projects include both bridge and road design, there are actually 22 comparisons made between in-house actual costs and simulated consultant costs. Nine bridge designs and thirteen road designs are included in the sample.

Cost comparisons and direct labor hour comparisons were made for the bridge and road sections. The in-house costs and hours are actual amounts charged to the projects. The consultant costs and hours are simulated by DOTD engineers according to the formula-based process used by DOTD to let contracts to consultants. It is important to realize, therefore, that the comparison being made is between actual in-house costs (and hours) to estimated consultant costs (and hours) that DOTD would have *paid* rather than costs (and hours) consultants might have *incurred.* The generalization of this comparison depends on the extent to which the formula approach used by DOTD reflects actual costs (and hours) experienced by consultants in general, and it also depends on the validity of the simulated consultant estimates in particular.

The audit division of DOTD periodically conducts man-hour studies to determine how the number of hours estimated by the formula compares to the actual hours incurred by consultants. Discussion with the audit manager in charge of these man-hour studies revealed that variances between estimated hours and actual hours was relatively small and did not suggest there was a systematic bias in the formula. However, it should be noted that projects in this sample were not subjected to man-hour studies, and most of the audits were done on cost plus contracts. Moreover, in practice, it is not the time (hours) a consultant actually takes, but how much the consultant actually is paid that is relevant to the comparison of in-house versus consultant costs.

Costs comparisons for both bridge and road projects appear in Table 34. The costs include labor, supervision, overhead, and direct costs for in-house and consultant projects.

Table 34
In-house project cost comparison

SP Eng.	Prelim. Plans	Final Plans	Bridge (Section 25) Consultant	In-House	% In-H./Cons.	Road (Section 24) Consultant	In-House	% In-H./Cons.
700-30-0208		X	286,538	245,881	86%			
700-27-0012		X	387,191	206,798	53%			
700-20-0070		X	91,933	101,596	111%	126,035	80,930	64%
700-20-0040		X	165,992	172,682	104%	124,198	117,041	94%
700-22-0007		X	60,744	33,031	54%			
700-39-0101		X	98,356	80,310	82%			
700-24-0082		X	343,768	249,413	73%			
700-27-0055		X	142,240	133,744	94%			
700-11-0024		X				284,666	240,524	84%
829-31-0001	X					57,352	13,567	24%
829-31-0001		X				55,420	20,967	38%
700-29-0108	X					62,412	26,905	43%
700-29-0108		X				74,437	21,677	29%
700-27-0037		X	91,575	40,368	44%			
700-27-0037		X				271,589	226,127	83%
700-30-0070	X					104,560	38,913	37%
700-30-0070		X				99,689	37,087	37%
700-26-0014	X					146,177	83,951	57%
700-26-0014		X				133,397	99,552	75%

In all cases, the in-house costs were less than costs that would have been paid to consultants. On average, in-house costs for bridge design were just under 76 percent of the simulated consultant costs. Among road projects, in-house costs were about 65 percent of those that would have been paid to consultants under the formula. Because of the large variation in project cost a weighted average was used. The differences, in both cases, are statistically significant at the 0.1 percent level. This means that if the same analysis had been done for the whole population, there is less than a 0.1 percent chance of arriving at a different conclusion. What accounts for the significant cost differences between in-house costs and those simulated for consultants? Because one possibility is that the *quantity* of hours is different, the comparison is repeated in Table 35, using number of hours only.

Table 35
Hour comparison

SP Eng.	Prelim. Plans	Final Plans	Bridge (Section 25) Hours			Road (Section 24) Hours		
			Consult.	In-House	% In-H./Cons.	Consultant	In-House	% In-H./Cons.
700-30-0208		X	4,133	4,301	104%			
700-27-0012		X	4,705	3,728	79%			
700-20-0070		X	1,172	1,772	151%	2,440	2,235	92%
700-20-0040		X	2,138	3,184	149%	2,328	2,678	115%
700-22-0007		X	755	761	101%			
700-39-0101		X	1,263	1,388	110%			
700-24-0082		X	4,461	3,899	87%			
700-27-0055		X	1,818	2,414	133%			
700-11-0024		X				5,873	7,076	120%
829-31-0001	X					1,090	491	45%
829-31-0001		X				1,077	670	62%
700-29-0108	X					910	566	62%
700-29-0108		X				1,040	517	50%
700-27-0037		X	1,160	829	71%			
700-27-0037		X				5,151	6,408	124%
700-30-0070	X					1,555	911	59%
700-30-0070		X				1,444	859	59%
700-26-0014	X					2,632	1,996	76%
700-26-0014		X				2,814	2,456	87%

The results of this comparison are mixed. Using a weighted average, in-house hours on the nine bridge projects exceed the simulated consultant hours by 3 percent, whereas in-house hours on the thirteen road projects were about 95 percent of the simulated consultant hours. Both results were not statistically significant, i.e. there is no evidence that there are differences between in-house hours and consulting hours for a project on the average. However, Table 35 also shows that smaller projects are designed with less hours in-house while large projects are more efficiently done by consultants.

The major outcome of the cost and hour comparisons shown in Tables 34 and 35 is that in-house costs are significantly lower for both bridge and road projects. This result can be attributed to differences in the *price* of labor, *indirect costs*, or some combination thereof. One major contributing factor is the higher amount of DOTD supervision for bridge design by consultants, which is 19 percent of consultant cost in Section 25 (bridge) but only 10 percent in Section 24 (road).

Approach 2: Analysis of Consultant Projects.

This section analyzes a sample of nine bridge or road projects representing 17 preliminary and/or final designs by consultants. In this analysis, actual consultant costs were compared with simulated in-house costs using consultant labor hour amounts and current DOTD average salary rates. The same formula used for estimating consultant costs was used for in-house cost estimation. Since State employees obtain a salary adjustment of 4 percent per year, 4 percent was used for the cost escalation factor for projects where this factor was included in consultant projects. The comparison uses indexed consulting salary rates to convert the consultant salary rates to the same time period, namely 1996. This index was computed as the ratio of salary rates from a salary survey of consultants in 1996 over the actual consulting salaries in the project year. This converts the consultant historical rates to the same time period as the in-house rates. The main difference to the example consultant fee computation shown in Table 13 is that profit, being inapplicable for DOTD, was deleted for in-house estimates. This analysis results in significant differences in both bridge and road design as shown in Table 36.

Table 36
Consultant project cost comparison

				Consulting		In-House		% In-H./Cons.	
SP Engineering	**Preliminary**	**Final**	**Letting Cost**	**Bridge**	**Road**	**Bridge**	**Road**	**Bridge**	**Road**
700-10-0023	X	X	$2,495,987	$80,721	$134,289	$66,757	$134,510	83%	100%
700-23-0072	X	X	1,526,216	63,467	142,484	53,001	118,317	84%	83%
700-29-0066	X	X	9,138,060	0	378,067	0	301,634		80%
700-25-0029	X	X	993,616	0	80,805	0	55,008		68%
700-22-0003		X	3,167,176	0	96,808	0	62,091		64%
700-24-0008	X	X	1,665,692	86,940	66,103	62,230	56,163	72%	85%
700-24-0029	X	X	1,074,508	25,252	63,433	21,777	56,910	86%	90%
700-22-0017	X	X	1,851,295	27,928	72,025	21,605	61,583	77%	86%
700-25-0020	X	X	5,491,587	22,100	119,097	9,581	88,501	43%	74%

Simulated in-house costs average 83 percent of consultant costs for bridge design and about 81 percent for road design. Again, because of the large variation in project costs, the weighted average was used. Both of these differences are statistically significant at the 5 percent level.

Approach 3: Comparison of Average Design Hour Costs.

Another approach is to eliminate the effect of extraneous factors by concentrating on the differences in costs caused by differences in the salary rates and overheads. The advantage of this approach is that it does not rely on the quality of individual simulations of projects, which is an additional factor of variation. Table 37 shows the mix of staff for 35 randomly selected consultant projects. Based on this sample, a percentage mix of staff was computed for consultants.

Table 37
Mix of staff for consultant projects

Type	Hours	% Type
Draftsman	13,689	30%
Technician	11,773	26%
Pre-Professional	8,934	19%
Engineer	7,963	17%
Supervisor	3,090	7%
Principal	370	1%
Total	45,819	100%

Using the average of the consultant staff mix in Table 37, the cost per hour of a representative consultant project can be computed. A similar computation can be done for in-house projects. While the percentage of staff mix cannot be computed for in-house projects, an average hourly cost can be obtained by dividing total in-house direct cost of the projects by the total number of hours used for the projects. This average of $15.03 is considered the direct payroll cost per design hour at the DOTD. Table 38 shows the computations of the respective hourly salary rates. Adding the costs of overhead, profit, and consultant contract initiation and supervision provides a further comparison of in-house and consultant costs.

The upper section of rows in Table 38 gives the average salary rates for DOTD and consultants. The middle section of rows provides the overheads. The percentage of total payroll is then computed without and with the cost of DOTD supervision. The bottom section of rows shows the effect of the overheads on cost per hour. The average payroll cost per hour in 1996 is $15.03 for the DOTD and $17.63 for consultants. Adding overhead, the average cost ranges from $43.07 to $47.04 at the DOTD and $48.47 for the consultants. This means that the cost per hour for in-house design is 89 percent that of consultants in Section 24 (road) and 97 percent in Section 25 (bridge), respectively. However, adding DOTD contract initiation and supervision for projects results in 77 percent (road) and 77 percent (bridge) of consultant costs. Table 38 also shows clearly the main causes for the cost differences; namely, the DOTD has a lower base salary rate, and the overall salary additives for consultant projects including DOTD supervision are higher than DOTD overhead.

Table 38
Estimated cost per project hour

	DOTD		Consultant	
Type	**Road**	**Bridge**	**Road**	**Bridge**
Draftsman			11.47	11.47
Technician			15.45	15.45
Pre-Professional			16.35	16.35
Engineer			26.14	26.14
Supervisor			32.23	32.23
Principal			40.18	40.18
Overhead	186%	212%	143%	143%
Profit	0%	0%	13%	13%
Total Percent Payroll Overhead	186%	212%	175%	175%
Contract (Section 18,24,25)			5%	6%
Supervision (Section 24/25)			10%	19%
Total Percent Payroll Additive Incl. Contr.	186%	212%	188%	193%
Total Percent Payroll Additive Incl. Contr.&Superv.	186%	212%	216%	244%
Direct Payroll	$ 15.03	$ 15.03	$ 17.63	$ 17.63
Direct Payroll+Overh.	$ 43.06	$ 46.90	$ 48.47	$ 48.47
DOTD/Consult(%) without Contr.&Superv.			89%	97%
Direct Payroll+Overh. +Contract	$ 43.06	$ 46.90	$ 50.75	$ 51.60
DOTD/Consult(%) with Contr.			85%	91%
Direct Payroll+Overh. +Contract&Supervision	$ 43.06	$ 46.90	$ 55.65	$ 60.71
DOTD/Consult(%) with Contr.&Superv.			77%	77%

An overhead rate of 143 percent is used for consultants since this is the value that was established by the department from a statewide survey. This is different from the 158 percent overhead rate for consultants derived from the 37 audits conducted by the department during the period 1995-96. The 143 percent is the official value used by the department and is, therefore, used here. However, the difference between the statewide average and audited values is not large and would not influence the findings in Table 38 significantly.

Conclusions

Table 39 summarizes the results of the three different approaches for comparing costs. Approach 1 comprises the analysis of in-house projects, Approach 2 analyzes consultant projects, and Approach 3 is cost differences. For Section 25, bridge design, all three approaches give about the same result, namely, that in-house designs are about 80 percent of the cost of consultant designs. For road design, Approaches 2 and 3 give the same result. However, Approach 1 leads to a lower percentage for road design. Taken together, the results suggest that a collective interpretation could be that in-house designs are in the order of 80 percent of the cost of consultant designs. Adding two standard errors to the averages in Table 39 we can conclude that with 95 percent confidence that the in-house cost is less than 96 percent of consultant cost for bridge design and less than 88 percent for road design.

Table 39
Comparison of approaches

Approach	Sample	Road		Bridge	
		Average	2xSTE	Average	2xSTE
1	In-House Projects	65%	14%	76%	16%
2	Consulting Projects	81%	7%	83%	13%
3	Cost per Design Hour	77%	N/A	77%	N/A

Note: 2xSTE represent two standard errors corresponding to a 95% confidence interval.

A review of the cost comparisons in Tables 34 and 36 show that there is substantial variation in the percentage of in-house cost over consultant cost. The question may arise as to which projects cost substantially less when done in-house, and which projects are just as cost-effective when done by consultants. Figure 11 shows the percent in-house over consultant cost plotted as a function of design cost divided by construction cost. The graph shows that as projects become more complex (i.e. the higher the percentages of design to construction cost) the consultant design costs become increasingly competitive with those of in-house designs.

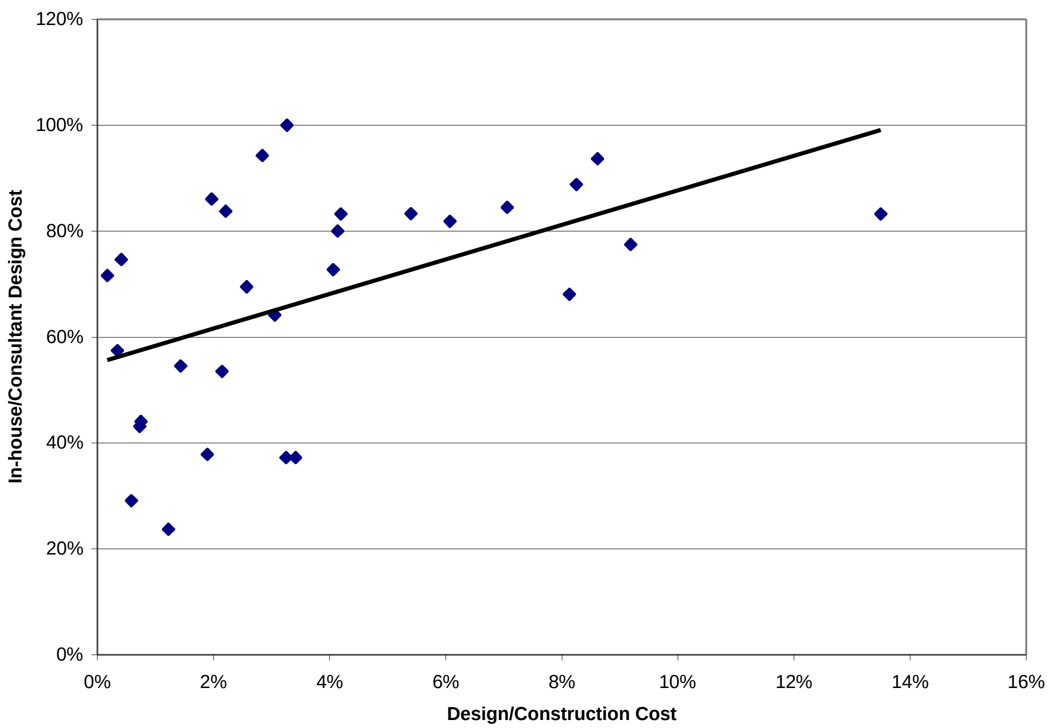

Figure 11
In-house/consultant design cost versus design/construction cost

Other factors

Introduction

Whereas the first objective of this study was to compare the cost of providing pre-construction engineering services by in-house staff or consultants, the second objective was to list other factors that are relevant to establishing an optimum balance between the use of in-house staff and consultants. In this section, factors other than cost are listed that should be considered in deciding on an appropriate level of involvement of consultants in the design activities of the department.

Findings from Other Studies

The Transportation Research Board sponsored a study in 1984 into the use of contract services in state Departments of Transportation (Cook, 1985). The study included a survey among all state DOT's to establish current practice. With more than 80 percent response rate in the survey, a full two-thirds of the respondents indicated that they do not use, or only occasionally use, cost as a factor in deciding whether to contract design work out to consultants or not. This indicates that in the case of the majority of state Departments of Transportation, cost is not even a significant factor in their decision to hire consultants to conduct design work.

The two main reasons given in the study above for the lack of significance of cost were "...(a) cost is not a major factor in contracting out and (b) the cost data for internal operations, especially overhead charges, are not sufficiently accurate to make meaningful comparisons."(Cook, 1985). Clearly, the majority of those responding to the survey felt that other factors are more important than cost in deciding on the level of consultant involvement in the design activities of their departments. In addition, they felt that comparisons between in-house and consultant design costs can never be made accurately anyway.

List of other factors

Following the review of the literature and discussions with engineers from both the private and public sector, some factors that are relevant to the issue of level of consultant use were identified. These factors are listed below, and while they are probably not exhaustive, they include several important factors to be considered.

Accommodating peak demand by using consultants. One of the common reasons quoted for using consultants to conduct some of the engineering designs required by a state Department of Transportation is the need to accommodate fluctuating demand for designs in the department. The implicit assumption is that consultants can more easily accommodate fluctuating demand than a state department because of their more flexible hiring and firing policy and their ability to function nationally and even internationally. Collectively, consultants are a large resource that can move to address needs across the nation as they arise. State departments are, obviously, limited to activity within their own department.

Increases in demand for road and bridge designs occurred during the 1980's. For example, Texas Department of Highways and Public Transportation reported a fourfold increase in payments to consultants for engineering services during the period 1980 to 1986 (Burke, et.al., 1987). Wisconsin reported a tenfold increase for design services during the period 1982 to 1989 (Wisconsin Legislative Audit Bureau, 1990). The consulting industry appears to have accommodated the increase in demand quite well and it is not clear how state departments would have handled the situation without the option of being able to turn to consultants.

Ability to meet deadlines. Closely associated with the issue of using consultants during periods of peak demand is the matter of meeting demands in a timely manner. As stated in the study conducted by the University of California, Berkeley, for CALTRANS, "There is no dispute as to whether it is more or less costly to use consultants. The issue is what resources are required and whether they be in-house staff or consultant staff for on-time delivery of the Capital Outlay Program" (Ashley, et.al., 1992, p. 289). It is likely that the productivity of in-house and consultant design staff is comparable, but consultants have a larger reservoir of manpower resources to draw upon and greater incentive to meet deadlines than does in-house staff, which also may be limited in its size. Consultants are more sensitive to meeting deadlines than in-house staff since their appointment to future projects depends in part on being able to submit designs by the due date.

Access to special expertise Few state Departments of Transportation can afford to retain specialized design expertise on their staff for complex designs that arise infrequently. Such specialized expertise could involve the design of large bridges or complex freeway interchanges. In such cases, it is more cost-efficient to make use of consultants to provide such expertise.

Allied to this issue is the matter of proficiency through experience. For example, if consultants are regularly used to perform certain types of designs, they are more likely to become more proficient in producing such designs. Similarly, in-house staff may, through custom, perform most of the designs of another type and, therefore, become more proficient in that area. Identifying such areas of distinct capabilities is an issue that administrators of the program should be mindful of in providing the most efficient delivery of designs for the department.

Use of consultants as an extension of the Department's workforce. Using consultants as an extension of a department's design workforce has the advantage that it allows ready adjustment of the workforce to serve demand, promotes smaller departmental staffing, and introduces competition in the work place. The arrangement provides more flexibility than would be available to in-house staff when they perform the majority of the work.

Economic effect. Contracting design work out to consultants helps support a healthy consulting engineering industry in Louisiana. The economic activity supports the generation of expertise and pays taxes. It can also serve to build up a resource, which in competing with other consulting engineering firms in the nation, can help to keep local funds within Louisiana and earn other contracts beyond the state's borders (Ward, et.al., 1987, p.59). A strong preference for the use of local consultants is expressed by most state officials, but if the local consultant base is not sufficiently strong to serve the needs, out-of-state consultants will have to be used for projects the department cannot conduct internally.

Qualifications of the consultants. _Qualifications-based selection of consultants not only serves to ensure quality of consultant design work, but it also serves to reduce the degree of departmental supervision needed. The Louisiana DOTD uses a rating system to evaluate the performance of its consultants, and this is used to identify those consultants who, in the opinion of the DOTD coordinators serving as contact persons between the consultants and the department, are the most efficient in performing their design tasks.

DOTD staff training and career development. From its survey among ten states, the Wisconsin Legislative Audit Bureau Study (1990) found that the estimated percent of total highway engineering contracts prepared by consultants as a percentage of all contracts let by the highway departments were:

Arizona	80%
Indiana	80%
Pennsylvania	75%
Florida	74%
Illinois	50%
Wisconsin	35%
Michigan	15%
California	15%
Iowa	<10%
Minnesota	<10%

In Louisiana, the level was reportedly 70-80 percent in 1994 (Jack, 1994). Clearly, in some states, consultants are handling the majority of the state's design activities. Can in-house staff retain the necessary design skills and experience to effectively check, evaluate, and approve designs without personal design experience? Indications are that a department can quickly lose (through resignations and transfers) the experience necessary to effectively supervise design activities in the department if there is not an ongoing design service being performed in the department (Lay, 1997).

Another factor is that in-house staff deserves the opportunity to develop their careers in the department in a meaningful way. Having no or little previous design experience adversely affects the ability of in-house staff to gain new experience for a career. If engineers are to be retained, career development opportunities must be maintained in the department.

CONCLUSIONS

The objectives of this study were: (1) to identify and compare the cost of providing pre-construction engineering services to DOTD when these services are provided by in-house staff or by consultants, and (2) list other factors that are relevant to establishing an optimum balance between the use of in-house staff and consultants in providing pre-construction engineering services. The following findings constitute the results of the study:

- The cost of providing road and bridge designs to DOTD is, on the average, lower when provided by in-house staff than by consultants. The best estimate of the average cost for in-house designs is that it is 81 percent the cost of consultant designs for road projects and 83 percent the cost of consultant designs for bridge projects. It can also be stated with 95 percent confidence that the average cost of in-house designs are less than 88 percent the cost of consultant designs for road projects and less than 96 percent the cost of consultant designs for bridge projects.

- The overhead rates of DOTD are 186 percent and 212 percent for Sections 24 (road design) and 25 (bridge design), respectively, whereas consultant overhead rates average 158 percent. However, adding profit makes consultant overhead rates increase to 192 percent, close to DOTD overhead rates. Adding DOTD consultant contract initiation and supervision makes consultant overhead rates higher than DOTD overhead rates, 236 percent and 265 percent, for road and bridge design, respectively.

- The difference in design costs between in-house staff and consultants is primarily due to the cost of consultant contract initiation and supervision.

- The cost for supervising consultant bridge designs is higher than for supervising consultant road designs, the average being 19 percent for bridge design and 10 percent for road design, while contract initiation is (5 percent and 6 percent of contract cost) for road and bridge designs.

- Supervision time on some consultant projects is 10-40 times greater than the most common supervision times.

- Direct labor chargeable to design by design-related DOTD staff averages 48 percent of total working hours, including leave, compared to an average of 63 percent for consultants.

- Man-hours for projects were not significant different between in-house and consultant designs. However, it appears that small projects tend to require fewer man-hours when done in-house, while large projects tend to require fewer man-hours when done by consultants.

- Salary rates with fringe benefits are very similar among DOTD design staff and consultants.

- The estimation formula for road designs has not been updated for several years and may not be accurate.

- Recording of time spent on in-house design is inadequate.

- Data on projects are all stored in a variety of databases without full cross-referencing.

- Consultant cost data, stored only in handwritten records, are difficult to retrieve and are vulnerable to loss.

- It is difficult, time-consuming, and sometimes impossible to extract cost information on projects.

- The project numbering system is inadequate for project cost control.

- The factors other than design cost that are relevant to establishing an optimum balance between in-house and consultant design work include the need to accommodate fluctuating design demand, being able to meet deadlines, having access to specialized expertise, having flexibility in workforce size, supporting the state’s consulting industry, maintaining a core of consultants who are experienced in departmental requirements and standards, maintaining in-house capability to effectively supervise consultants, and maintaining an environment in the Department which adequately serves the training and career development needs of in-house staff.

RECOMMENDATIONS

Recommendation #1

DOTD should consider all relevant factors when deciding an optimum balance between in-house and consultant design work.

Recommendation #2

The work assigned to consultants should be given to experienced consultants to minimize departmental supervision.

Recommendation #3

The formulae to estimate design costs should be updated regularly.

Recommendation #4

An attempt should be made to increase the proportion of time charged to design by in-house design staff to more closely match that of consultants.

Recommendation #5

The recording of time spent on in-house designs needs to be improved.

Recommendation #6

The project numbering system needs to be improved for effective project cost control.

Recommendation #7

The present information system needs to be upgraded to an integrated client-server system capable of providing timely, accessible, and useful information to engineers and managers for both in-house and consultant projects.

Recommendation #8

A total quality management program should be implemented to determine sources of variation in cost and quality of both in-house and consultant designs.

AREAS OF FURTHER STUDY

Information System

The DOTD information system is not capable of providing useful cost information for internal as well as for external users. Further studies need to be conducted to analyze information needs and establish a system that serves the department's needs. The information system used at DOTD does not provide timely cost information about in-house or consulting engineering projects nor does it permit the tracking of cost of engineering designs. There are too many unrelated databases keeping information about projects, and too many different legacy programs are used. The industry trend is moving away from mainframe computers to a client-server environment using integrated software which:

- Satisfies operational, financial and managerial principles simultaneously,
- Uses a common database,
- Provides point-of-data entry,
- Features consistency for users across applications,
- Allows on-line, interactive edit and update,
- Eliminates redundant data, and,
- Ensures data integrity.

Off-the-shelve software such as SAP (Systems Applications and Products in Data Processing) is available and could provide such an integrated approach to information systems. For instance, a simple query, which would take a professional person five minutes in a client server environment using an integrated software package now takes more than a week at the DOTD. This is due to the elaborate procedure for processing queries on data records in the DOTD. Requests for reports need to be submitted to the computer center manually by filling out a paper form. These requests are queued and processed as time permits. In some cases, as occurred during this study, a Cobol program had to be written to download the accounting data. In contrast a good reporting system should be flexible and should meet both external and internal requirements. Integrated software allows viewing data once it is entered in the system, provided authorization is given. Currently, no records of consulting costs are kept on the computer, and partial information on projects is kept in various unrelated databases.

The separation of the end user of information (engineer and managers) and information handler (the computer center) leads to inefficiencies and reduces quality of information. For example, in the execution of this study, two requests for the same accounting data done by different personnel in the computer center led to different sets of data. Since the programmers do not understand the meaning of the data, they were unable to reconcile the difference. The responsibility for data integrity should be with the staff which uses the data, not with the computing center. Staff should be able to query databases which lie in their area of responsibility. That is, a manager supervising a project should be able to obtain timely information about the cost of the project without going through the computer center.

Project Cost Control

Further studies need to be done to improve cost control of engineering design projects. At present, there seems to be no effective overall cost control of design projects in existence at the DOTD. This is partly due to the lack of pertinent information available as pointed out above. However, there is also no attempt to identify cost drivers of design projects, whether they are done in-house or by consultants. For instance, 41 percent of the 83 selected projects discussed in Section 4 have an engineering to construction cost ratio above 5 percent. Two percent of the projects had engineering cost of over 20 percent. No use of statistical data is made to identify common and special causes for increased cost.

Quality of Designs

Further studies should be done to identify the cost of quality of design engineering. Although it is well known within the DOTD that the cost of projects varies significantly, there seems to be no attempt made to identify the source of this variation. Quality begins with measurements and without measurements, there is no ability for improvement. Further studies should be done to identify sources of variation in project cost and supervision of consulting projects with the goal of reducing variation. For instance, if contract initiation and supervision of bridge design projects stays at a level of 25 percent, there is no incentive for contracting out bridge designs. However, the cost of supervision ranges from 7 to 70 percent. Hence, in some cases contracting out may be worthwhile. Some consulting projects have up to 10 amendments. Many projects have to be redone by the time they are going to be let. It is important to identify the causes for these amendments that may lead to increased cost. Although all projects are controlled individually, there seems to be no appreciation of statistical quality control. Without collecting statistical data on cost and quality indicators, no improvement can be achieved. It is important to distinguish between common cause and special cause variation in order to reduce the cost of quality. For instance, projects performed in stages may be more cost effective if done in-house. Many consulting projects have several supplements stretched over several years. These projects often have to be redone because of necessary changes. In some cases, the consultant went out of business and the design had to be redone. Also, projects done in stages may reduce the DOTD's bargaining power during contract negotiations.

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