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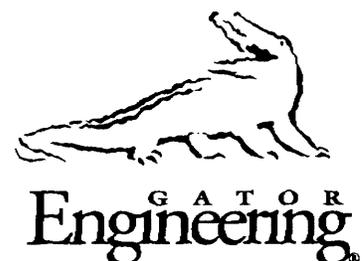
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**Best Management Practices for the Out-Sourcing of Design  
and Construction Engineering Services on  
FDOT Construction Projects**

**December 2000**  
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Disclaimer:

The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the State of Florida Department of Transportation.

## TECHNICAL SUMMARY

This report presents information developed as a part of a research project sponsored by the Florida Department of Transportation (FDOT) and being performed by the University of Florida. The principal focus of the study is on the use of management consultants to obtain construction administration, management, engineering and inspection services.

This report provides information obtained from the Florida Department of Transportation (FDOT) and other Transportation Agencies concerning their management approach and costs associated with agency management of construction projects. The FDOT uses the term "Construction Engineering and Inspection (CEI)" for this activity. The information contained in this report focuses on three primary study areas:

1. Establishing baseline costs ranges for industry
2. Analysis of FDOT cost trends
3. Identifying various management approaches and suggesting strategies for improvement

Project cost information obtained from the FDOT indicates that their CEI cost when performing management with their own forces averages 9.22 % of the construction contract cost. The FDOT's cost when using outside consultants averages 14.67 % of construction contract cost. This cost included 11.57 % for consultant contract cost and 3.10 % for the FDOT's administrative cost. A more detailed categorical analysis of FDOT costs is contained in the report.

The majority of State Highway Agencies (State Highway Agency) reported using outside consultants to augment their CEI activities. The average cost reported for performing CEI with in-house forces was 8.60 % of construction contract cost. The average cost reported for performing CEI with outside consultants was 11.07 % of construction contract cost. It should be noted that there was considerable variation in reported CEI cost from agency to agency.

An analysis of FDOT CEI cost data was performed including 1402 projects from the period of 1994 to 1999. Cost trends are presented for both FDOT cost and consultant cost. Suggestions are presented for allocating CEI responsibility based on cost effectiveness.

Transportation Agencies were surveyed with regard to their consultant procurement and contract compensation methods. These consultant management procedures are detailed in this report. Additionally, best practice management strategies were developed from analysis of the information received from the FDOT and other State Highway Agencies. Suggestions for further research and an implementation plan are included.

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## **INTRODUCTION**

In recent years, the Florida Department of Transportation (FDOT) has faced a significant increase in the size of its annual construction work program. The FDOT has chosen to handle the increased workload by contracting out to private industry sources much of the construction engineering and inspection (CEI) work once traditionally performed by FDOT personnel. This strategy has permitted the FDOT to manage a greater volume of work without assuming the long-term obligation of additional personnel positions. However, the use of consultants to perform CEI services presents many new management challenges for the FDOT. Programmed costs and manpower estimates are based on historical records. CEI costs have become a significant component of total project cost for the FDOT. The FDOT realizes that effective and efficient management of CEI services is fundamental to the future of the FDOT. However, there has been no research to analyze the management practices of the FDOT and other State Highway Agencies to identify best management practices with regard to out sourcing construction administration and management functions. Without this knowledge, it is difficult for the FDOT to establish effective production measures and to establish appropriate contracting and management procedures.

The basic purpose of this study was to determine the best management practices for the use of consultants for construction engineering and inspection services. A fundamental first step in this study was to establish baseline cost and management procedures for the FDOT and other State Highway Agencies.

Additionally, a detailed analysis of FDOT CEI cost history was conducted to develop an understanding of the relationships between cost factors effecting CEI cost on FDOT projects.

This cost analysis provides useful management information on cost trends and suggestions for improved cost efficiency.

Best practice management strategies were developed from analysis of the information received from the FDOT and other State Highway Agencies. Suggestions for further research and an implementation plan are included.

A cost database was obtained from the FDOT including a project by project listing of CEI cost for FDOT construction projects during the program years of 1994 to 1999. A total of 580 projects were included in the database. Analysis of CEI cost was performed for projects where consultants were used and for projects where CEI functions were performed by FDOT personnel. Costs were also analyzed by project type and project size.

Interviews were conducted with FDOT construction managers to determine current administrative and management procedures for

FDOT CEI functions. The scope of issues discussed included: consultant procurement, scope of services, compensation format and FDOT management of consultant contracts.

### **INFORMATION FROM OTHER STATE HIGHWAY AGENCIES**

Working with FDOT managers a survey questionnaire was designed to capture basic cost and management procedures information of interest from other State Highway Agencies. The first step was to identify by telephone or by E-mail the individual within the State Highway Agency that was capable of providing the requested information. Following this initial contact, survey forms were faxed to the appropriate individual information source. Surveys were sent to all states, Puerto Rico and Guam, and all Canadian Provinces. 52 surveys were sent. A copy of the survey form is enclosed as Appendix A. Forty-eight responses were received. The information received was analyzed and summarized.

# SURVEY OF STATE HIGHWAY AGENCIES USE OF CEI CONSULTANTS

## FDOT Procedures and Costs

The FDOT generally uses CEI consultants to handle workload requirements that are above the capacity of their internal construction management resources. Consistent with the overall work plan projects are assigned either to in-house management or designated for CEI consultant management. During the program years of 1994 to 1999, the FDOT elected to use CEI consultants on 141 projects and to use in-house personnel on 439 projects. CEI consultants were used on 24.3 % of the projects. The total construction contract value of the projects using CEI consultants was \$770,840,046, which represented 69.2 % of the FDOT's total project volume of \$1,114,426,930.

The CEI consultant procurement process is similar to the process used to acquire design consultant services. Figure 1. presents a graphic illustration of the procedure used by the FDOT for acquiring CEI consultant services.

Step One	Advertise and receive letters of interest from consultants
Step Two	Evaluate interested firms and select short-list
Step Three	Short-listed firm submit a proposal package
Step Four	Oral presentations
Step Five	Winner is selected

Table 1. The FDOT CEI Consultant Procurement Process

The format for compensating CEI consultants is presented in Figure 2 below.

	Direct Hourly Labor at Agreed Upon Hourly Wage Rates
Plus	Multiplier x Direct Hourly Labor
	<hr/> Total Labor
Plus	Margin (10-15%)x Labor
Plus	Other Direct Expenses
	<hr/> Total Lump Sum Contract Amount

Figure 1. Method of CEI consultant Compensation

It is notable that profits are limited to cost incurred in the original performance period. Profits are not allowed on cost incurred during delay periods.

The scope of services required for FDOT CEI consultants essentially covers all administrative activities and project responsibilities normally performed by the FDOT. This requires complete staffing of the project from the technician or inspector level up through project engineers and managers. The FDOT assigns a Project Manager to oversee the activities of the CEI Consultant. Depending on the size and complexity of the projects, an FDOT Project Manager may be responsible for several CEI Consultant managed projects.

The FDOT CEI Consultant contract cost averaged 11.6 % of the construction contract amounts for the 580 projects reviewed. In addition, FDOT cost for managing the CEI Consultant contracts averaged 3.10 % of the construction contract cost. The average total cost on the CEI projects was 14.7 % of the construction contract costs.

Project Size (\$ million)	Constuction Expenditure	CEI Expenditure	% Contract Expenditure
0.1<	\$260,671.00	\$123,038.00	47.20%
0.1<0.5	\$13,888,020.00	\$3,146,382.00	14.77%
1.0<5.0	\$166,225,884.00	\$23,469,015.00	14.12%
5.0<10.0	\$197,947,243.00	\$25,177,972.00	12.72%
10.0<20.0	\$172,594,831.00	\$17,474,741.00	10.12%
20.0<	\$219,923,397.00	\$19,774,061.00	8.99%

Table 2. Average CEI Consultant Costs Listed Categorically by Project Size.

The FDOT CEI cost for projects managed in-house with FDOT personnel averaged 9.22 % of the construction contract amounts for the 580 projects reviewed. Table 3. presents the average CEI costs for projects managed in-house listed categorically by project size.

Project Size (\$ million)	Constuction Expenditure	DOT CEI Expenditure	% Contract Expenditure
0.1<	\$6,384,249.00	\$1,769,788.00	27.72%
0.1<0.5	\$91,209,236.00	\$11,272,377.00	12.36%
1.0<5.0	\$150,465,898.00	\$12,469,341.00	8.29%
5.0<10.0	\$60,003,591.00	\$3,724,531.00	12.72%
10.0<20.0	\$0.00	\$0.00	0.00%
20.0<	\$0.00	\$0.00	0.00%

Table 3. DOT managed CEI expenditure by Project Size

### **Other State Highway Agencies Procedures and Costs**

A complete listing of the survey responses is enclosed, as Appendix A. Summaries of the responses are presented in this section of the report.

## Survey Results for State Highway Agencies Responding

### Question 1

*“Does your organization utilize consultants to perform construction engineering and inspection (CEI) services on your construction projects?”*

Yes 85.4%      No 14.6%

### Question 2

“For projects in which you perform the CEI functions with your own DOT personnel, what is the estimated average CEI cost as a percentage of total construction contract cost?”

Minimum Reported 0.5% (discounting this value 3.0%)

Maximum Reported 15.0%

Average Reported 8.6%

Figure 2. presents a histogram of the cost percentages reported in response to question 2.

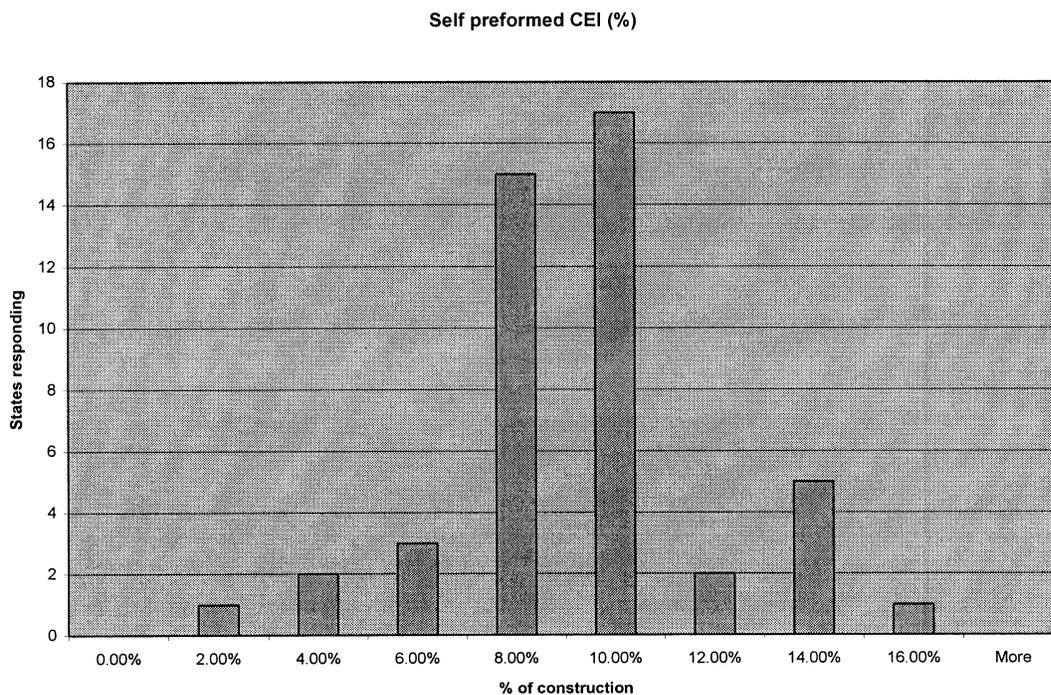


Figure 2. self-reported State Highway Agency performed CEI expenses as % of construction

### Question 3

“For projects in which your consultants perform CEI functions, what is the estimated average CEI cost as a percentage of total construction contract costs?”

Minimum Reported 0.7% (discounting this value 2.0%)

Maximum Reported 22.0%

Average Reported 11.07%

Figure 3, presents a frequency histogram of the cost percentages reported in response to question 3.

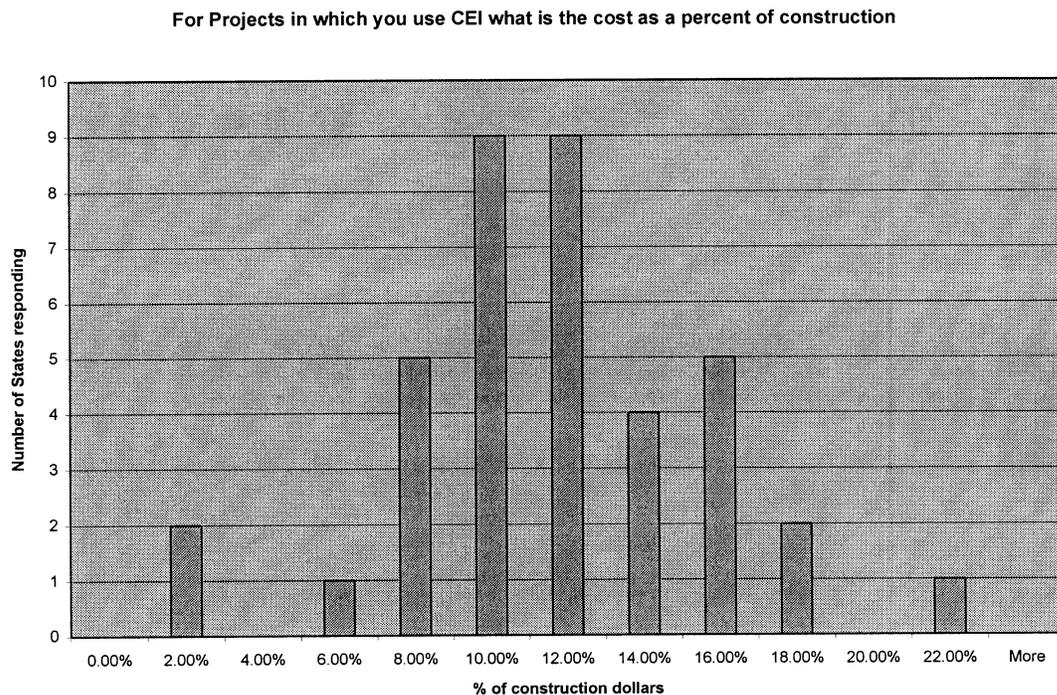


Figure 3. State Highway Agency reported consultant perform CEI expenditure as % of construction

### Question 4

”In what year did you begin using CEI consultants?”

Minimum Reported Time less then one Years

Maximum Reported Time more then 49 Years

Average Reported Time 9.5 Years

### Question 5

“When you utilize consultants for CEI services, what is their typical scope of work?”

Personnel Staffing Only 54%

Comprehensive Management 73%  
Sampling and Testing 41%  
Other Services 17%

**Question 6**

“If you use consultants to perform CEI services, what is the average salary rate by class?”

State Highway Agencies reported consultant pay rates for various project staffing positions. Respondents used their own position titles, which varied considerably from state to state. Table 4. presents a representative listing of staffing positions and consultant pay rates. A complete listing of the responses is enclosed as Appendix B.

Postion Reported	Pay Rate
Proj Manager	\$ 37.00
Sr. Inspector	\$ 25.00
Lead Tech	\$ 18.00
Tech Bases	\$ 16.00
Lab Tech	\$ 15.00
Admin	\$ 12.00
Eng Tech 2	\$ 11.44
Eng Tech 3	\$ 13.06
Eng Tech 4	\$ 14.90
Eng Tech 5	\$ 16.24

Table 4. CEI Staffing positions and pay rates

**Question 7**

“What methods of compensation are used in the consultant’s contracts Lump Sum?”

Lump Sum 24%

Cost Plus Fixed Fee 68%

Cost Plus a Percentage 23%

**Question 8**

“Do you allow for the payment of overtime by the consultant?”

Yes 77.5% No 22.5%

### **Question 9**

“When using a consultant for CEI services, who in the DOT oversees the consultant’s contract?”  
 State Highway Agencies reported various position titles for their supervisor of CEI consultant contracts. Respondents used their own position titles, which varied considerably from state to state. Table 4. presents a representative listing the resources. A complete listing of the responses is enclosed as Appendix B.

DCE or designee
District Rep
Project Contract Admin
District engineer
Engineer in Charge
Seperate CEI supervisor
District Project Engineer
Res Con Eng & DCE

Table 4. Typical Responses to question 9 of Survey

### **Question 10**

“Do you have any special training requirements for the personnel overseeing consultant CEI contracts?”

11 State Highway Agencies have a Formal Training Program

29 State Highway Agencies with Training Programs Under Development

### **Question 11**

“Is the CEI consultant in Responsible Charge as defined by the FHWA?”

15 State Highway Agencies reported that CEI Consultants are in Responsible Charge

24 State Highway Agencies reported that CEI Consultants are not in Responsible Charge

## **FDOT CEI COST DATA ANALYSIS**

After analyzing the data set provided by the FDOT, it was determined that an additional metric would be need to fill in missing data points. The cause for this was thinning of the original data set when analyzing smaller components of the data set. For example when work mix codes were investigated 86 different work mix codes of the FDOT defined set of 183 codes were represented. Of the 86 different work mix codes represented in the data set, both the FDOT's own forces and CEI consultants had preformed only 38 work mix types. Of the 38 work mixes that remained to be evaluated 12 had sufficient data to make comparisons between the FDOT and the CEI cost of construction.

## **MISSING DATA AND TREND LINES**

After analyzing the data set provided by the FDOT, it was determined that an additional metric would be need to fill in missing data points. It was decided to build an index of FDOT self-performed projects and compare these with FDOT+ CEI expenses. This cost index was used to fill in missing year for creation of comparison sets of FDOT and CEI data. The Raw data used to generate the Cost index is included in the section called Methodology below. Additional sections are include which relate some narrative information about each of the plots presented in figure 4

## **METHODOLOGY**

The existing data set included projects from 1989 to 1999; the data was organized by year of project completion. The cost data was then used to compute average cost for self-preformed project and for out-sourced projects. Since out sourcing did not occur before 1992, the basis for comparison was set to 1992=100. Subsequent years were compared to this benchmark. Two trends appeared which had not been observed previously. These trends were the apparent

increase in efficiency of the FDOT in self-performed work and the fluctuations in the CEI preformed project efficiencies.

Year	FM \$	DOT	DOT %	FMS CEI	CEI	CEI%	DOT	DOT super	DOT+CEI
1989	\$ 603,952.00	\$ 89,719.00	14.86%	\$ -	\$ -	-	\$ -	-	-
1990	\$ 7,580,134.00	\$ 1,411,182.00	18.62%	\$ -	\$ -	-	\$ -	-	-
1991	\$ 6,613,713.00	\$ 1,324,338.00	20.02%	\$ -	\$ -	-	\$ -	-	-
1992	\$ 6,430,062.00	\$ 1,949,490.00	30.32%	\$ 420,665.00	\$ 18,282.00	4.35%	\$ 29,882.00	7.10%	11.45%
1993	\$ 14,631,876.00	\$ 2,636,094.00	18.02%	\$ 621,378.00	\$ 27,250.00	4.39%	\$ 76,945.00	12.38%	16.77%
1994	\$ 14,974,536.00	\$ 2,009,511.00	13.42%	\$ 1,352,156.00	\$ 194,773.00	14.40%	\$ 55,505.00	4.10%	18.51%
1995	\$ 23,740,326.00	\$ 3,214,621.00	13.54%	\$ 14,802,887.00	\$ 1,802,934.00	12.18%	\$ 638,408.00	4.31%	16.49%
1996	\$ 35,433,354.00	\$ 4,517,124.00	12.75%	\$ 12,955,135.00	\$ 892,723.00	6.89%	\$ 559,954.00	4.32%	11.21%
1997	\$ 175,958,464.00	\$ 19,857,217.00	11.29%	\$ 341,319,122.00	\$ 45,009,603.00	13.19%	\$ 12,694,248.00	3.72%	16.91%
1998	\$ 213,491,528.00	\$ 22,804,227.00	10.68%	\$ 388,958,168.00	\$ 48,811,077.00	12.55%	\$ 14,862,268.00	3.82%	16.37%
1999	\$ 51,206,688.00	\$ 5,461,894.00	10.67%	\$ 57,953,238.00	\$ 11,786,421.00	20.34%	\$ 1,758,042.00	3.03%	23.37%

Table 6. Cost index data 1989 to 1999 for FDOT, CEI and FDOT supervision

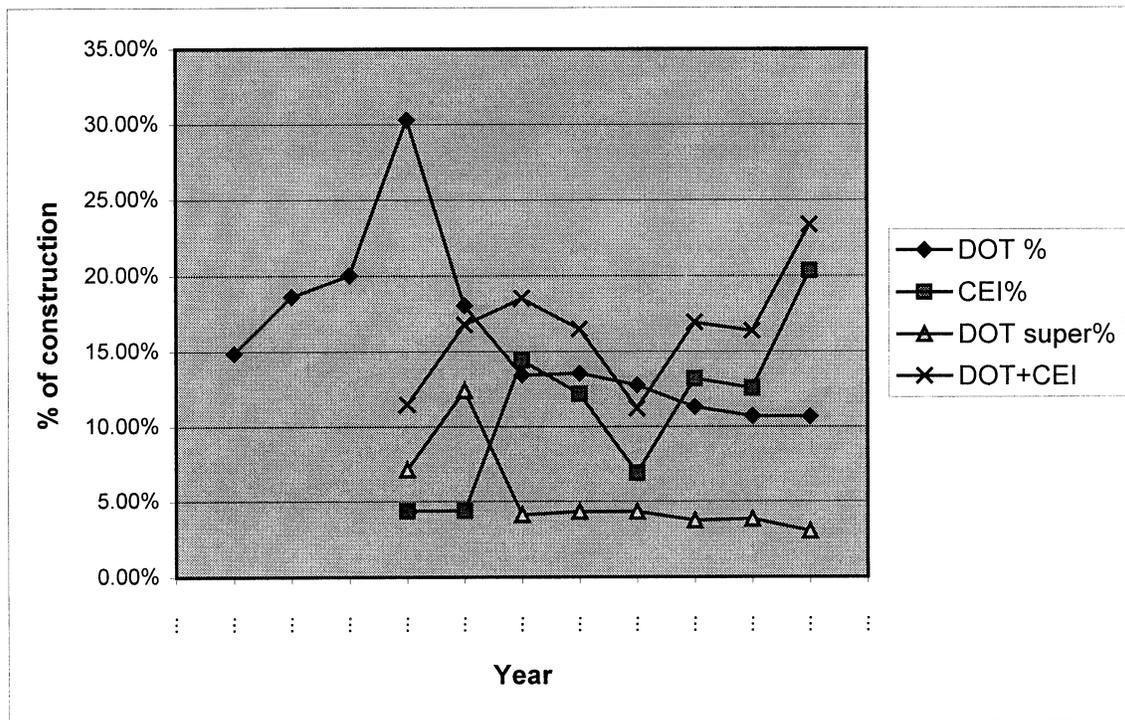


Figure 4. Cost as % of Construction 1989 to 1999 for FDOT, CEI and FDOT supervision

### FDOT Self-performed Projects

The FDOT showed a remarkable improvement in efficiency in the completion of self performed work. Starting 1992 with a base percent of construction cost of 30.32%. This value is deceptive in

that 1992 was the highest cost of construction year in the data set. Below is a table containing cost data vs. year of completion for the projects used to create the cost index.

Year	DOT+CEI %	DOT %
1989		
1990		
1991		
1992	100.00	100.00
1993	146.46	59.42
1994	161.66	44.26
1995	144.04	44.66
1996	97.94	42.05
1997	147.66	37.22
1998	142.98	35.23

Table 7. Cost vs. Year of Completion

### **CEI expenses**

In the interval from 1992 to 1999, the cost of out sourcing projects has generally increased. In 1992 and 1993 there was little change in CEI costs however, starting with 1994 CEI costs have generally increased. In 1996, there was an abrupt decrease in CEI costs. The cause for this sudden decrease was not readily discernible. Additional research would be required to determine the cause for this decrease. The area of greatest opportunity for the FDOT appears to be in working with CEI consultants to decrease their costs.

## **FDOT Supervision Costs**

The FDOT has decreased its cost to supervise CEI work. There are many reasons that may account for this. Some of these possible reasons are listed below.

- Increased cost efficiency of supervision due to larger FM contract amounts
- Improved skill on the part of FDOT project managers in supervision of CEI consultants
- Improved skill on the part of CEI consultants, thus requiring less supervision
- Bundling of CEI contract so that FDOT personal can more effectively supervise the projects

The effect of the practices should be considered for further evaluation.

## **ALLOCATION TEST STRATEGY**

The data provided by the FDOT was divided by work mix codes and the marginal cost of having a project performed by a CEI was computed. These data was used to create and initial matrix for project allocation. However, the results of this allocation were not acceptable. A second allocation strategy was created based on the trends occurring in the cost of CEI projects. This strategy produced a more acceptable outcome. Both of the allocation strategies are explained in detail in the following two sections.

### **INITIAL ALLOCATION STRATEGY**

Based on the trends it was concluded that the FDOT should prefer to allocate projects based on CEI efficiency. This efficiency was evaluated by comparing the marginal cost of having the CEI perform the duties that the FDOT would normally perform. In essence, the cost difference between the self-preformed costs of the FDOT was subtracted from the sum of the FDOT supervision and CEI costs for the same work mix projects. These values are summarized in table

8 below. However, the results of this strategy yielded no significant savings. There were two primary reasons for this.

- Some of the “better” work mixes were not performed in the data set evaluated
- In some cases allocating a project differently than the historical method actual lead to increased costs to the FDOT for the same project.

Work mix code	Description	CEI%	DOT%	DOT+CEI	DOT ONLY	Delta %	Desirability
121	MULTI-LANE RECONSTRUCTION	13.18%	2.37%	15.55%	2.25%	13.30%	1
421	REPLACE LOW LEVEL BRIDGE	17.42%	8.20%	25.63%	13.56%	12.07%	2
24	BRIDGE-REPAIR/REHABILITATION	13.18%	4.28%	17.46%	7.85%	9.61%	3
119	INTERSECTION (MINOR)	20.12%	5.35%	25.48%	16.71%	8.77%	4
12	HWY-RESURFACING	12.58%	3.09%	15.66%	9.27%	6.40%	5
220	FEDERAL AID RESURFACE/REPAVE	13.14%	2.79%	15.94%	10.52%	5.42%	6
9917	SAFETY PROJECT	6.45%	8.55%	15.00%	9.66%	5.34%	7
429	BRIDGE REHABILITATION	13.11%	2.55%	15.66%	10.71%	4.95%	8
9924	MISC. CONSTRUCTION	14.45%	3.19%	17.64%	14.54%	3.09%	9
213	ADD LANES & RECONSTRUCT	10.82%	4.14%	14.96%	12.28%	2.68%	10
46	ENVIRONMENTAL ACTION	10.17%	1.38%	11.56%	10.71%	0.85%	11
549	ADD LEFT TURN LANE(S)	1.75%	8.00%	9.75%	13.68%	-3.93%	12

Table 8. Test Strategy Matrix Initially used to allocated projects

## SECOND ALLOCATION STRATEGY

Using the Cost index created, missing data was inserted into the 12 remaining work mix codes. These work mix codes encompassed over 50% of all the projects (by dollar amount) in the data set. Of these 12 codes, it was discovered that 8 codes show increasing cost trends and that 3 show decreasing cost trends, while one had essentially unchanged cost trends. These trends accounted for the undesirable outcome of the initial allocation strategy. Using the same rational approach of allocation based on marginal cost-desirability, a new table was created which attempts to forecast the cost matrix for these projects. In the case of the 8 work, mix codes which showed an increasing trend, the FDOT should consider self-performing these projects. Were the CEI cost trend showed increasing efficiency, the FDOT may wish to allocate as many projects to consultants as possible. Table 3a-d which follow summarize the remaining 12 work mix codes

and provide trend information. The complete data set used to generate table 9 is located in appendix A.

Year	Increasing Work Mix 12			Year	Increasing Work Mix 24			Year	Increasing Work Mix 46		
	CEI&DOT	DOT	Delta		CEI&DOT	DOT	Delta		CEI&DOT	DOT	Delta
90				90			0.00%	90		38.99%	
91				91			0.00%	91		43.87%	
92		13.03%		92			0.00%	92		28.85%	
93		14.11%		93	16.22%	12.56	3.66%	93		14.15%	
94				94	17.33%	9.53	7.80%	94		19.65%	
95		16.21%		95	15.44%	5.83	9.62%	95	13.37%	12.33%	1.04%
96	14.53%	9.80%	4.73%	96	9.24%	6.97	2.27%	96	10.86%	5.37%	5.49%
97	13.92%	9.56%	4.35%	97	14.64%	7.56	7.08%	97	16.37%	13.58%	2.79%
98	15.92%	9.26%	6.66%	98	29.84%	7.19	22.65%	98			
99	20.54%	5.91%	14.62%	99	21.27%	7.57	13.70%	99			

Table 9a. FDOT vs. CEI cost trends by year and work mix code

Year	Increasing Work Mix 119			Year	Decreasing Work Mix 121			Year	Increasing Work Mix 213		
	CEI&DOT	DOT	Delta		CEI&DOT	DOT	Delta		CEI&DOT	DOT	Delta
90	0.00%	19.75%		90				90			
91	0.00%	29.78%		91				91			
92				92				92			
93	17.93%	22.57%	-4.65%	93				93			
94	19.79%	27.46%	-7.67%	94				94			
95	17.63%	10.93%	6.70%	95				95	7.78%	14.87	-7.09%
96	15.72%	14.58%	1.14%	96				96	15.97%	13.16	2.80%
97	23.70%	17.77%	5.93%	97	16.92%	11.35	5.57%	97	14.13%	12.18	1.95%
98	34.85%	12.52%	22.32%	98	15.26%	14.54	0.72%	98			
99	49.75%	20.23%	29.52%	99	11.66%	23.21	-11.56%	99			

Table 9b. FDOT vs. CEI cost trends by year and work mix code

Year	Decreasing Work Mix 220			Year	Unchanged Work Mix 421			Year	Increasing Work Mix 429		
	CEI&DOT	DOT	Delta		CEI&DOT	DOT	Delta		CEI&DOT	DOT	Delta
90				90				90	0.00%	17.33%	
91				91				91	0.00%	10.77%	
92				92				92	11.45%	21.68%	
93				93				93	16.77%	15.61%	1.16%
94				94	32.31%	11.83%	20.48%	94	18.51%	12.25%	6.26%
95				95	28.79%	11.94%	16.85%	95	15.00%	6.31%	8.69%
96				96	25.22%	11.24%	13.98%	96	14.01%	11.20%	2.81%
97	22.74%	12.58%	10.16%	97	38.02%	9.95%	28.07%	97	15.30%	7.47%	7.83%
98	14.46%	9.98%	4.49%	98	21.00%	13.11%	7.89%	98	20.18%	9.23%	10.96%
99				99	37.11%	13.09%	24.02%	99			

Table 9c. FDOT vs. CEI cost trends by year and work mix code

Year	Increasing Work Mix 549			Year	Increasing Work Mix 9917			Year	Decreasing Work Mix 9924		
	CEI&DOT	DOT	Delta		CEI&DOT	DOT	Delta		CEI&DOT	DOT	Delta
90				90				90		38.99%	
91				91				91		43.87%	
92	6.60%	48.98	-42.38%	92				92		28.85%	
93	9.67%	23.53	-13.86%	93				93		14.15%	
94	10.67%	14.45	-3.78%	94				94		19.65%	
95	9.51%	8.57	0.94%	95				95	34.72%	19.92%	14.79%
96	6.46%	14.27	-7.80%	96	12.95%	8.80%	4.15%	96	14.78%	13.08%	1.70%
97	9.75%	10.45	-0.70%	97	13.96%	19.53%	-5.57%	97	22.28%	13.75%	8.53%
98	9.44%	17.08	-7.65%	98	14.44%	7.97%	6.47%	98	20.40%	11.07%	9.34%
99	13.47%	9.97	3.50%	99	19.52%	9.64%	9.88%	99	11.66%	23.21%	-11.56%

Table 9d. FDOT vs. CEI cost trends by year and work mix code

## **DAILY COST OF CONSTRUCTION INSPECTION AND SUPERVISION**

Based on the historical data set provided by the FDOT, an analysis of the daily cost of construction inspection and supervision was conducted. This analysis can be broken into two areas, regression analysis and trend plotting.

### **REGRESSION ANALYSIS**

It was felt that a regression analysis of the daily cost would help produce an estimate of future cost trends. The regression analysis was performed on work mix code 9924 “Miscellaneous Construction.” The Work Mix Code was selected due to the large sample size and number of years it has been being performed by both the DOT and CEI consultants.

#### **First Regression**

The daily cost was selected as the dependant variable. The independent variables were the number of days, the contract amount and the use of CEI consultants. The results appeared on the next page.

<i>Regression Statistics</i>								
Multiple R	0.2							
R Square	0.0							
Adjusted R Square	0.0							
Standard Error	752.6							
Observations	121.0							
ANOVA								
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>			
Regression	3.0	6,124,941.88	2,041,647.29	3.60	0.02			
Residual	117.0	66,280,190.19	566,497.35					
Total	120.0	72,405,132.07						
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	431.8	96.01	4.50	0.00	241.69	621.99	241.69	621.99
Days	-0.5	0.32	-1.80	0.07	-1.21	0.06	-1.21	0.06
Contract Amount	0.0	0.00	1.16	0.25	0.00	0.00	0.00	0.00
Consultant Used	559.1	239.94	2.33	0.02	83.98	1,034.36	83.98	1,034.36

Table 10. First Regression Analysis for Work Mix Code 9924

As can be seen from the low Adjusted R square this selection for independent variables did not seem to be strongly tied to the dependent variable. However, the t Stat values can be useful in determining the importance of one independent variable when compared to another. There are indications that the most important component of the daily cost is the Intercept value. This represents the cost, which is inherent in the function and is present regardless of other factors. The next most significant factor is the use of a consultant on a project.

### **Second Regression**

With a mind toward the low adjusted R square values obtain in the initial regression analysis it was felt that date of project completion should be included to account for inflation and other time value of money elements. Regression analysis was repeated with the addition of year of completion. The results of this analysis are presented page 21.

<i>Regression Statistics</i>									
Multiple R	0.41								
R Square	0.17								
Adjusted R Square	0.14								
Standard Error	719.64								
Observations	121.00								
ANOVA									
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>				
Regression	4.00	12,331,681.26	3,082,920.32	5.95	0.00				
Residual	116.00	60,073,450.81	517,874.58						
Total	120.00	72,405,132.07							
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>	
Intercept	10,823.37	3,003.05	3.60	0.00	4,875.45	16,771.30	4,875.45	16,771.30	
Date	-109.41	31.60	-3.46	0.00	-172.01	-46.82	-172.01	-46.82	
Days	-0.33	0.31	-1.06	0.29	-0.95	0.29	-0.95	0.29	
CONTRACT	0.00	0.00	1.70	0.09	0.00	0.00	0.00	0.00	
Consultant?	738.41	235.18	3.14	0.00	272.60	1,204.21	272.60	1,204.21	

Table 11. Second Regression Analysis of Work Mix Code 9924

Although the results of this analysis yielded a higher adjusted R square value, it would not be advisable to make prediction of cost based upon this analysis. By looking at the t Stat values we see that the most important factor is still the Intercept value. However, the date of completion supercedes the use of a consultant as the next most important factor.

**PLOTTED TRENDS FOR WORK MIX CODES AND DAILY COST OF CONSTRUCTION SUPERVISION AND INSPECTION**

After the results of the regression analysis, it was desirable to plot the data to see if any trends could be observed. Data for the historical projects was divided by work mix codes and the average daily cost was computed on an annual basis. The following figure presents the results of this information graphically. There are 11 work mix codes plotted on the figure and they show a similar trend.

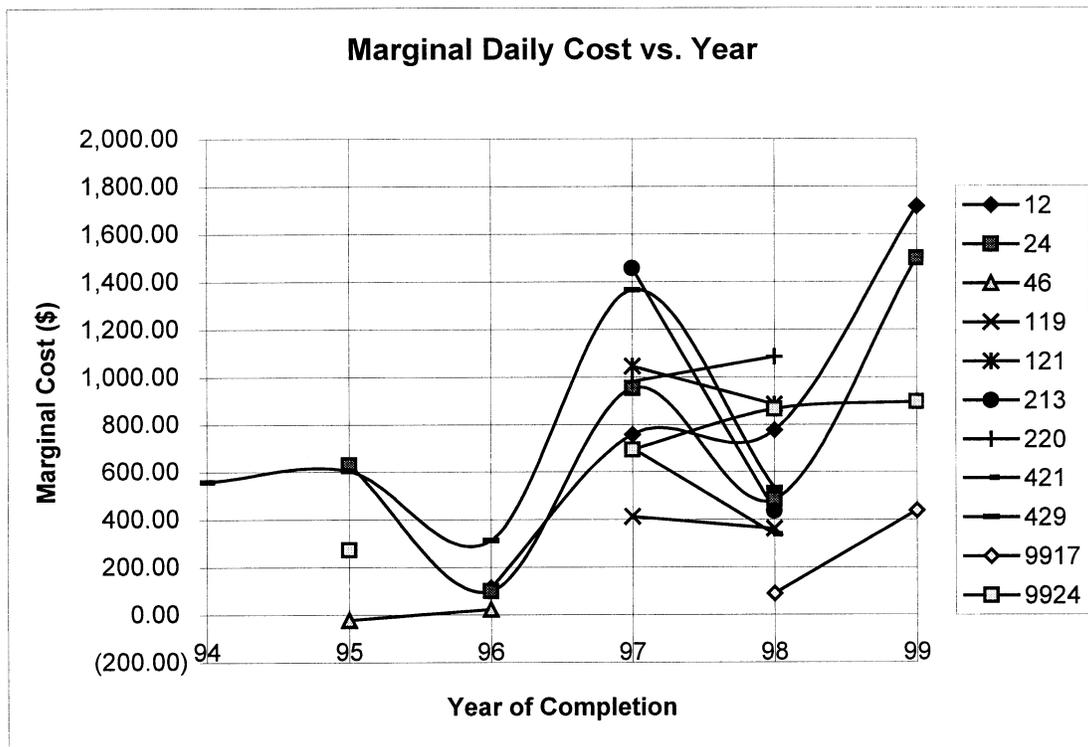


Figure 5. Marginal Daily Cost vs. year of Completion.

The causes for the collective change in daily cost are not understood. However, these variations would be sufficient to explain the inability of regression analysis to produced satisfactory results.

These oscillations in the marginal cost would also help to explain why the allocation strategies attempted were not always successful.

The data tabulated to create this table includes the number of projects preformed by consultants and the FDOT. This data is included in appendix C.

## WORK MIX AND DOLLAR SIZE OF PROJECTS

An additional attempt was made to determine which projects should be self-performed and which should be given to consultants to perform. This approach used two variables to determine which projects should be self-performed. The first variable was the project size and the second was the project work mix code.

### ALLOCATION BY PROJECT SIZE

When faced with a given project it might be desired to allocate a project based exclusively on its size. The projects in the historical dataset can be broken into 4 cost divisions. These divisions each contain approximately 25% of all FDOT projects. These divisions are as follow.

- \$0 to \$100,000
- \$100,000 to \$250,000
- \$250,000 to \$700,000
- Projects greater than \$700,000

The following table indicates the marginal cost of construction when using a consultant to perform a project. The Desirability of the project is based on giving preference to using FDOT personal on projects, which have the highest marginal cost first. The size column is 0, is projects between \$0 and \$100,000. These divisions are summarized above.

Size	Total dollars	CEI Dollars	CEI	DOT Super	DOT only	% DELTA	Desirability
0	\$ 9,225,026.00	\$ 111,258.00	\$ 21,286.00	\$ 1,791.00	\$ 1,775,868.00	1.26%	4
100000	\$ 40,119,763.00	\$ 3,926,325.00	\$ 754,989.00	\$ 240,893.00	\$ 5,436,862.00	10.34%	1
250000	\$ 58,923,274.00	\$ 13,508,784.00	\$ 1,822,776.00	\$ 748,997.00	\$ 5,716,547.00	6.45%	2
700000	\$646,748,867.00	\$443,989,750.00	\$53,706,378.00	\$16,136,954.00	\$19,796,469.00	5.97%	3

Table 12. Allocation of Projects by Marginal Cost and Size.

### ALLOCATION BY SIZE AND WORK MIX CODE

The concept of allocation by size can be enhanced if we look at both the work mix code and the project size simultaneously. As would be expected, consultants perform with varying degrees of economic efficiency on different projects. This is true for the FDOT as well. What is presented on the following page is a summary of the marginal costs of using consultants to perform work instead of the FDOT. Consultants have succeeded in performing work more efficiently than FDOT for 5 combinations. These combinations appear as negative values. It would be desirable when allocating projects to ensure that consultants were used for these projects due to their historical superiority in their performance. Recognizing that the work volume far exceeds the work capacity of the FDOT, for projects with positive values, it would be advantageous to allocate the projects with the largest marginal cost values to the FDOT. When the FDOT work capacity is reached, additional projects would be assigned to consultants. Other factors such as, resources available at the district level may influence this choice. However, cost effectiveness should remain a critical guideline when planning project management.

Workmix	Size	Total dollars	CEI Dollars	CEI	DOT Super	DOT only	% DELTA	Sufficient	Rank
12	100000	\$ 274,906.00	\$ -	\$ -	\$ -	\$ 75,396.00	none	NO	
24	100000	\$ 3,476,790.00	\$ -	\$ -	\$ -	\$ 477,196.00	none	NO	
46	100000	\$ 150,483.00	\$ 56,945.00	\$ 8,962.00	\$ 1,791.00	\$ 36,413.00	-20.05%	NO	
119	100000	\$ 518,744.00	\$ -	\$ -	\$ -	\$ 89,980.00	none	NO	
121	100000	\$ -	\$ -	\$ -	\$ -	\$ -	none	NO	
213	100000	\$ -	\$ -	\$ -	\$ -	\$ -	none	NO	
220	100000	\$ -	\$ -	\$ -	\$ -	\$ -	none	NO	
421	100000	\$ -	\$ -	\$ -	\$ -	\$ -	none	NO	
429	100000	\$ 2,338,749.00	\$ -	\$ -	\$ -	\$ 481,760.00	none	NO	
549	100000	\$ 481,384.00	\$ -	\$ -	\$ -	\$ 112,985.00	none	NO	
9917	100000	\$ 156,868.00	\$ -	\$ -	\$ -	\$ 45,431.00	none	NO	
9924	100000	\$ 1,827,102.00	\$ 54,313.00	\$ 12,324.00	\$ -	\$ 456,707.00	-3.07%	NO	
12	250000	\$ 1,523,112.00	\$ -	\$ -	\$ -	\$ 237,270.00	none	NO	
24	250000	\$ 6,337,314.00	\$ 751,416.00	\$ 43,955.00	\$ 11,149.00	\$ 495,543.00	-1.54%	OK	14
46	250000	\$ 1,183,647.00	\$ 589,542.00	\$ 77,573.00	\$ 4,732.00	\$ 61,810.00	3.56%	NO	10
119	250000	\$ 4,163,722.00	\$ 351,689.00	\$ 125,183.00	\$ 22,539.00	\$ 852,963.00	19.63%	NO	
121	250000	\$ 165,082.00	\$ -	\$ -	\$ -	\$ 51,195.00	none	NO	
213	250000	\$ 625,324.00	\$ -	\$ -	\$ -	\$ 117,541.00	none	NO	
220	250000	\$ 1,743,944.00	\$ -	\$ -	\$ -	\$ 356,088.00	none	NO	
421	250000	\$ 4,021,480.00	\$ 1,185,592.00	\$ 330,366.00	\$ 59,721.00	\$ 439,362.00	17.41%	NO	
429	250000	\$ 5,245,328.00	\$ 341,506.00	\$ 101,023.00	\$ 51,470.00	\$ 506,753.00	34.32%	NO	
549	250000	\$ 4,923,410.00	\$ 152,146.00	\$ 27,757.00	\$ -	\$ 727,413.00	3.00%	NO	
9917	250000	\$ 536,266.00	\$ 191,714.00	\$ 861.00	\$ 25,596.00	\$ 64,379.00	-4.88%	NO	
9924	250000	\$ 9,651,134.00	\$ 362,720.00	\$ 48,271.00	\$ 65,686.00	\$1,526,545.00	14.98%	NO	
12	700000	\$ 16,174,211.00	\$ 2,837,037.00	\$ 278,906.00	\$ 169,052.00	\$1,521,166.00	4.38%	OK	9
24	700000	\$ 15,058,109.00	\$ 4,249,781.00	\$ 319,316.00	\$ 312,257.00	\$ 978,584.00	5.81%	OK	8
46	700000	\$ 1,922,204.00	\$ 1,922,204.00	\$ 177,981.00	\$ 29,950.00	\$ -	none	NO	
119	700000	\$ 5,939,550.00	\$ 338,848.00	\$ 6,143.00	\$ 53,145.00	\$ 859,908.00	2.14%	NO	
121	700000	\$ -	\$ -	\$ -	\$ -	\$ -	none	NO	
213	700000	\$ -	\$ -	\$ -	\$ -	\$ -	none	NO	
220	700000	\$ -	\$ -	\$ -	\$ -	\$ -	none	NO	
421	700000	\$ -	\$ -	\$ -	\$ -	\$ -	none	NO	
429	700000	\$ 3,719,146.00	\$ 1,415,796.00	\$ 163,767.00	\$ 94,831.00	\$ 223,506.00	8.56%	OK	3
549	700000	\$ 5,456,266.00	\$ 569,888.00	\$ 69,103.00	\$ 29,955.00	\$ 753,226.00	1.97%	NO	
9917	700000	\$ 2,161,066.00	\$ 482,156.00	\$ 103,839.00	\$ 30,490.00	\$ 273,270.00	11.58%	NO	
9924	700000	\$ 8,492,722.00	\$ 1,693,074.00	\$ 703,721.00	\$ 29,317.00	\$1,106,887.00	27.02%	NO	
12	700000+	\$180,813,731.00	\$111,462,694.00	\$14,097,186.00	\$3,359,373.00	\$5,996,363.00	7.01%	OK	5
24	700000+	\$ 65,354,415.00	\$ 43,942,765.00	\$ 6,089,161.00	\$1,769,745.00	\$1,287,409.00	11.87%	OK	1
46	700000+	\$ -	\$ -	\$ -	\$ -	\$ -	none	NO	
119	700000+	\$ 4,979,488.00	\$ 1,749,860.00	\$ 359,700.00	\$ 54,999.00	\$ 396,164.00	11.43%	NO	
121	700000+	\$ 76,250,951.00	\$ 59,223,254.00	\$ 7,805,896.00	\$1,404,357.00	\$2,160,934.00	2.86%	OK	13
213	700000+	\$159,964,065.00	\$137,852,109.00	\$14,909,405.00	\$5,711,427.00	\$2,674,127.00	2.87%	OK	12
220	700000+	\$ 36,515,954.00	\$ 16,047,498.00	\$ 2,108,928.00	\$ 448,315.00	\$1,980,548.00	6.26%	OK	7
421	700000+	\$ 23,529,583.00	\$ 9,929,291.00	\$ 1,606,399.00	\$ 852,090.00	\$1,789,520.00	11.60%	OK	2
429	700000+	\$ 33,981,725.00	\$ 28,522,575.00	\$ 3,703,923.00	\$ 625,501.00	\$ 399,657.00	7.86%	OK	4
549	700000+	\$ 10,998,504.00	\$ 5,307,709.00	\$ 8,575.00	\$ 452,319.00	\$ 571,164.00	-1.35%	NO	
9917	700000+	\$ 17,482,765.00	\$ 9,866,732.00	\$ 574,915.00	\$ 845,613.00	\$ 563,584.00	7.00%	OK	6
9924	700000+	\$ 36,877,686.00	\$ 20,085,263.00	\$ 2,442,290.00	\$ 613,215.00	\$1,976,999.00	3.44%	OK	11

Table 13. Allocation by Size and Work Mix Code with Marginal Cost of Construction

## **BEST MANAGEMENT PRACTICES**

### **COST FACTORS**

The review of the FDOT historical project cost data indicates that overall cost of construction project administration and management (CEI services) is influenced by following cost factors:

1. Choice of utilizing consultant services
2. Project Size (Dollar amount of the construction contract)
3. Project Type (FDOT Work Mix Number)
4. Scope of Services (for consultant utilization)
5. Market Conditions (for consultant utilization)
6. Supplemental Agreements (changes in project duration and contract amount)

The above factors do directly affect overall project cost. Program cost management involves applying sound management judgment with regard to the cost factors.

It should be noted that project quality and timeliness was not found to be influenced by any of the above factors. Although quality and on-time completion does vary from project to project, analysis indicates that this variation is directly influenced by the project participants: designer, contractor and owner's representative.

### **SCOPE OF SERVICES**

Determining the appropriate scope of services to obtain from a CEI consultant is a key management issue. Consultant cost is primarily staffing and equipment costs. Project staffing requirements are directly related to the administrative tasks assigned to the consultant. This study indicates that much variability exist with the use of CEI services by different State Highway Agencies. Some states such as Georgia utilize consultants primarily to supply temporary personnel to the project to augment the DOT's own forces. The consultant-supplied

personnel may be at both the technician or engineer levels. Georgia maintains project management responsibility and control with Georgia DOT personnel. On the other hand, many states assign complete project management duties to the consultant.

However, some administrative functions may be performed more efficiently when centralized. For example, human resource regulatory compliance matters might be more efficiently handled, if centralized at the resident or district level, rather than by a consultant on a specific project. Administrative functions that can be more efficiently performed by the State Highway Agency should not be included in the consultant scope of services.

Additionally, the project management process as defined by contract, specifications and established procedures should be critically reviewed. Tasks and requirements that do not add value to the project should be eliminated. Consultant cost is directly effected by the work process assigned by the State Highway Agency.

### **PROCUREMENT PROCEDURES**

Consultant selection and contract negotiation procedures are important. The most successful State Highway Agencies maintained the following features in their CEI consultant procurement process:

1. Utilizing a sound qualification system that efficiently measures the consultant's capabilities. Focus is on the qualifications of the individuals to be assigned to the specific project.
2. Past performance, evaluations of CEI consultants are maintained and considered.
3. State Highway Agency project managers develop a detailed management plan for each project before consultant negotiations. The State's plan provides a basis for discussion when reviewing the plan proposed by the consultant.

4. Standard rates for different staff levels and equipment cost are established and utilized in all CEI consultant contract pricing.

### **MULTIPLE PROJECT CONTRACTS**

Providing a full project staffing on a construction project from beginning to end is not an efficient management strategy. Projects often encounter delays. Even projects without unexpected delays have differing levels of work activity throughout the project duration. Contractors and in many cases the State Highway Agencies shift resources from project to project, applying people where they are needed. The consultant may be required to maintain the same staffing level on a project for its duration. This inefficiency adds to consultant cost.

Several State Highway Agencies on a trial basis are negotiating consultant contracts where several projects have been bundled together. The consultant is then able to make more efficient use of resources over a multi-project program.

South Carolina is implementing a program where two primary consultants will be acquired to manage all of the state's CEI projects. These two prime consultants will procure sub-consultants to perform on individual projects. The anticipated advantages of this system include:

1. More continuous experience and knowledge base
2. More flexibility in applying resources

### **SELECTION OF PROJECTS**

The issue is determining for a specific project who should perform the CEI function: the FDOT or a CEI consultant. Analysis of the FDOT project cost records indicates that significant differences exist in average CEI cost for different project types and different project sizes.

Improvements in the overall program CEI cost can be obtained by assignment of CEI

responsibility to the party who will be most cost effective. At the same time, we must recognize that the internal resources of the State Highway Agency are relatively fixed. The state can only handle a certain volume of project work with its own forces (unless the state work force is increased). Therefore, work volume beyond the capacity of the state's internal forces must be allocated by default to consultants.

State Highway Agency internal forces should be assigned projects for which they are most cost effective and for which consultants are least cost effective. When the capacity of the state's work force is reached, additional projects must be covered using CEI consultants. This approach was detailed and presented in section label "ALLOCATION TEST STRATEGY" of this report.

### **SUGGESTED BEST PRACTICES**

Based upon analysis of the FDOT's situation and input received from other State Highway Agencies a number of Best Practices have been developed. These concepts are presented in Figures 7 to 11.

<b>Concept No. 1</b>	
<b>Eliminate non-cost effective tasks from the CEI scope of services.</b>	
<b>Management Strategy: Assign to the CEI consultant only those task that can be efficiently performed by the consultant. Retain responsibility for task that can be more efficiently performed by established State Highway Agency organization. Periodically review project procedures and eliminate non-value adding tasks.</b>	
Advantages	The work process will be more efficient and overall project cost will be reduced.
Disadvantages	The state must invest management time in performing review and analysis of current project procedures.
Conditions Necessary for Success	Accurate cost records must be maintained. Procedures must be reviewed by a team with diverse membership.
Potential Concerns	Contracting practices and procedures may have to be revised.
Cost Implications to DOT	Potential cost savings can be directly estimated from the reduction in staffing requirements and applied to the total work program.
Implementation Plan	Scope of services should be developed for each project based upon the project requirements and the availability of alternative sources.
Overall Potential for Success	The potential for success would appear to be very high.

Figure 7. Best Practice Concept No. 1

<b>Concept No. 2</b>	
<b>Insure that the outcome of the consultant negotiation will be a staffing plan, which is appropriate for the specific project at an appropriate cost.</b>	
<b>Management Strategy: Establish standard procedures for managing the CEI consultant procurement process. Include in those procedures the development of a project work plan and staffing requirement by experienced FDOT engineers before discussions with consultants. Review the proposed scope of services considering the specifics requirements of each project.</b>	
Advantages	The consultant procurement process will be more efficient and will result in purchasing consultant services, which are the best match for the project.
Disadvantages	The state must invest management time in developing standard procedures. Project managers must invest time in developing project plans before consultant negotiation.
Conditions Necessary for Success	Standard procedures must be developed and implemented with top management support.
Potential Concerns	Some flexibility must be allowed within the procedures to accommodate unique project requirements.
Cost Implications to DOT	The FDOT will be purchasing only those services and staffing that are required for individual projects. Non-value adding items will be eliminated.
Implementation Plan	The FDOT should form a Task Team to review consultant procurement procedures and to make recommendations. Approved changes should be implemented in the CEI consultant contracting procedures throughout the state.
Overall Potential for Success	The potential for success would appear to be very high.

Figure 8. Best Practice Concept No. 2

<b>Concept No. 3</b>	
<b>When possible use multi-project consultant contracts.</b>	
<b>Management Strategy: Establish guidelines for the formation of multi-project CEI consultant contracts. When possible contract with the consultant for multiple projects within a period. Allow consultants to develop an over all program plan for staffing the contracts.</b>	
Advantages	The direct cost to the CEI consultant will be reduced. The FDOT should realize cost savings with CEI consultant cost.
Disadvantages	Work will be concentrated with fewer consultants. Managing multi-projects will present increased management challenges for the consultant.
Conditions Necessary for Success	Work programs at the District level must be reviewed and opportunities for utilizing multi-project contracts must be identified.
Potential Concerns	Guidelines should be developed for developing the program packages and for the consultant procurement.
Cost Implications to DOT	Consultant CEI cost will be reduced because of the increased efficiency.
Implementation Plan	Guidelines should be developed for the preparation and management of multi-project consultant contracts. Procedures should be implemented in the CEI consultant contracting throughout the state.
Overall Potential for Success	This procedure has been used on a limited basis with success. The potential for success would appear to be very high.

Figure 9. Best Practice Concept No. 3

<b>Concept No. 4</b>	
<b>Allocate CEI Responsibility on the Basis of Cost Effectiveness</b>	
<b>Management Strategy: Maintain a continually updated analysis of project costs history. Monitor CEI cost trends and develop cost analysis with regard to project size and type. Assign to FDOT forces those projects that are least cost effective when performed by consultants.</b>	
Advantages	The FDOT will be using its limited resources in the most cost effective manner. CEI cost per project dollar will be reduced. Savings may be used to accomplish additional projects within the same budget.
Disadvantages	The FDOT will have to invest management time in maintaining an analyzing project cost data.
Conditions Necessary for Success	Organization and analysis of project cost data must be performed.
Potential Concerns	The value of this approach will improve as the density of the cost data increases.
Cost Implications to DOT	Consultant CEI cost will be reduced because of the increased efficiency.
Implementation Plan	Procedures should be implemented for allocating project responsibility based upon historical cost trends. Development of the work plan should include allocation planning.
Overall Potential for Success	Significant savings in project CEI cost can be achieved.

Figure 10. Best Practice Concept No. 4

<b>Concept No. 5</b>	
<b>Avoid and Minimize Project Delays</b>	
<b>Management Strategy: Increasing project duration directly increases CEI cost. Management attention should be given to delay avoidance and mitigation. Sources for delays are varied and no single remedy exists. However, utilities and plan errors remain a frequent causes.</b>	
Advantages	The direct cost to the CEI consultant will be reduced. The FDOT will receive the added benefits of completing the project on time and avoiding non-value adding construction claims costs.
Disadvantages	None.
Conditions Necessary for Success	The FDOT must continue to address the root causes for project delays. This will involve internal efforts and the use of external research products.
Potential Concerns	Rapid expansion of the work program has strained the human resources capacity of the FDOT and the CEI consultants.
Cost Implications to DOT	Consultant CEI cost will be reduced.
Implementation Plan	Completing projects on time must be established as a priority adopted by all project participants. Everyone must be accountable for their performance. The FDOT should continue to apply management attention and to acquire research initiatives in developing strategies to avoid delays.
Overall Potential for Success	Even marginal improvements in project time performance will result in significant benefits.

Figure 11. Best Practice Concept No. 5

## **DISCUSSION OF RESEARCH RESULTS**

### **USE OF CEI CONSULTANTS BY State Highway AGENCIES AND THE FDOT**

Investigation indicates that the use of outside consultants by transportation agencies to augment their own construction management forces is wide spread. 85 % of State Highway Agencies reported using consultants. There is considerable variability with regard to the experience of different State Highway Agencies with the use of consultants. For example, California has never used consultants and Connecticut has been using consultants for 50 years. The reported cost of CEI consultant services also varied. Reported CEI consultant cost ranged from 0.7 % to 22.0 %. Performing CEI activities with in-house personnel was reported to be an average of 2.44 % less than the cost of using outside consultants. The cost data on FDOT projects indicated that Florida's costs are approximately equal to the nationwide averages. Florida's reported CEI cost consultant was 11.57 %. The average of all reported CEI consultant cost was 11.07 %. It must be acknowledged that while FDOT's cost data was developed from a comprehensive audit of project cost, many of the cost reported from other State Highway Agencies are "estimates". However, interviews conducted by the research team with the respondents suggest that the precision of the data is adequate to present a fair representation of industry cost benchmarks. Based upon this information it is suggested that the variation can be attributed one or more of the following causes.

- Inaccurate estimates of actual costs
- Differences in the scope of services included
- Differences in labor rates (salary cost is the largest direct cost component in construction services consulting)
- Differences in contracting and management practices
- Differences in choice of projects to which outside consultants are assigned

## **ANALYSIS OF FDOT PROJECT COST DATA**

### **Cost Trends**

Analysis which has been performed on the 1402 project data set provided by the FDOT for investigation into a best management practice for the selection of project to be out-sourced to CEI consultants.

### **Effect of Project Size and Project Type on CEI Cost**

The results of the data analysis indicates that the project size does not have as strong an effect on the cost of CEI as does the work mix code of the particular project. In general, there are large variations in the data set used to perform this analysis and additional data would be need for more complete understanding of the phenomenon.

Investigations into the effect of supplemental agreements might prove beneficial in trying to understand the variations. Figure 13 on the next pages show that the trend of marginal daily cost and cost as a percent of construction seems to be following a similar pattern.

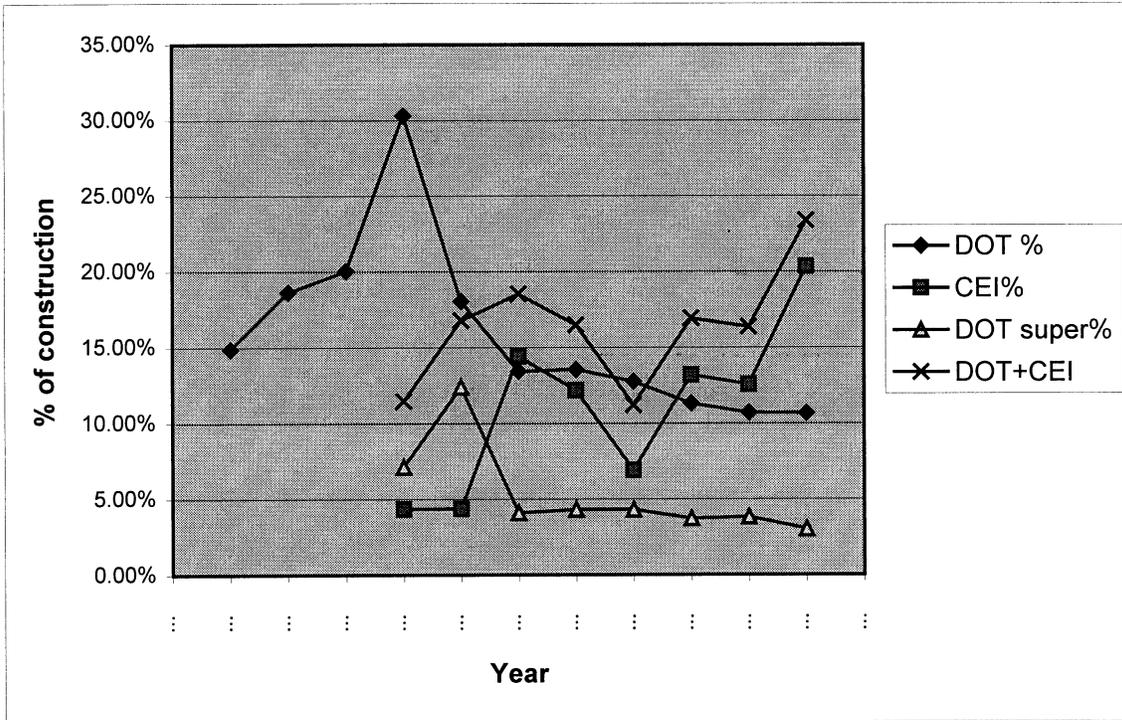


Figure 12. Cost as % of Construction dollars 1989 to 1999

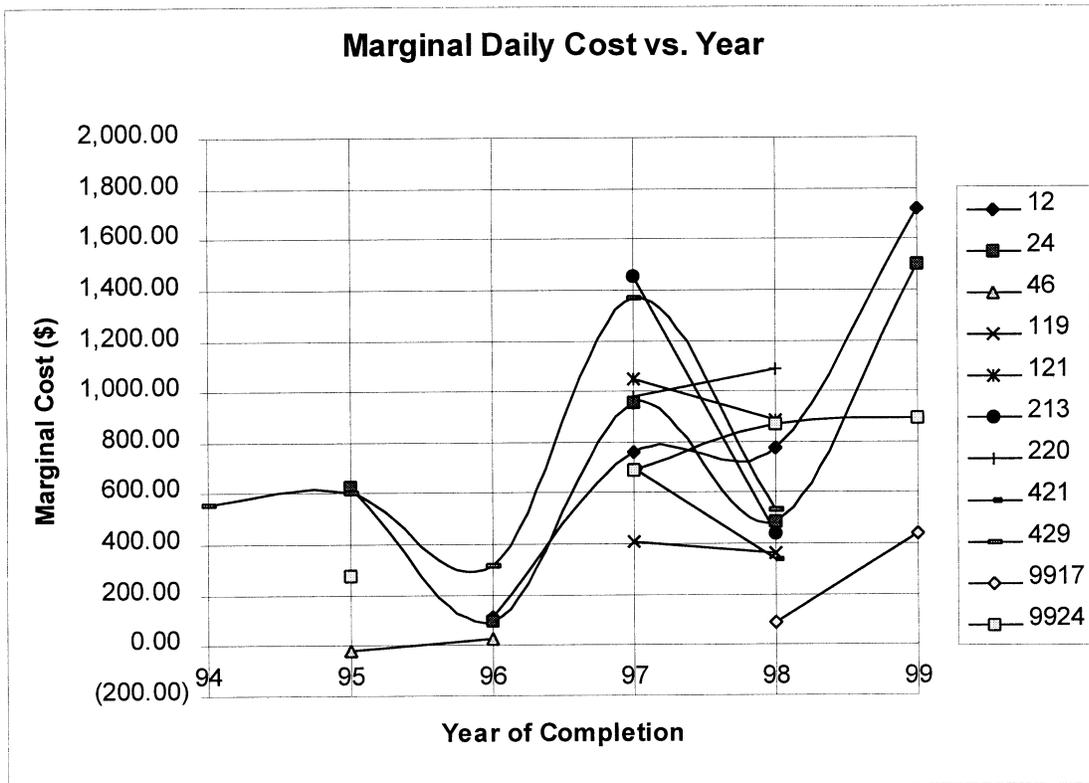


Figure 13. Marginal cost by work mix code and year

## **ALLOCATION ON THE BASIS OF COST EFFECTIVENESS**

Based on the data there are variations in the average consultant cost and the FDOT cost for performing a given work mix code. Prediction of future costs is limited due to a lack of density in the data. However, the data does indicate that preferences or guidelines exist for selecting project that should be performed with limited capacity of the FDOT.

There are 2 factors that can improve the precision of project allocation, additional data and increased understanding of cost trends.

### **ADDITIONAL DATA**

Additional data would help increase the accuracy of allocation by allowing more reliable metrics to be developed. Although over 1400 projects were in the initial data set, data thinning occurred. This created a small pool of project work mix codes that could be evaluated.

Additional data is a time dependent function. As such, additional data is being generated all the time.

### **UNDERSTANDING COST TRENDS**

A better understanding of variability in the cost data could be accomplished by additional research. When combined with a larger data sample more accurate predictions of future costs should result.

# RECOMMENDATIONS AND IMPLEMENTATION PLAN

## RECOMMENDATIONS

### **Management Practices**

Based upon the research results and discussions with senior FDOT managers the research team recommends the following actions:

1. Conduct a review of the Best Practices developed in this section of the report at both the top management and project level within the FDOT.
2. Select those concepts that have the greatest potential for success.
3. Initiate an implementation plan for the selected best practices.

### **Management Information**

The FDOT should design and implement a CEI cost information system to provide cost and management information concerning CEI cost within the FDOT's work program. Information from this system will assist managers with future planning decisions. The current cost database provides total actual CEI cost. The effect of project changes on the cost is not recorded.

### **Future Research**

The FDOT should initiate additional research to develop an understanding of the key characteristics of the FDOT CEI cost history. Specifically the following items are of interest:

1. Analysis of the cost data indicates that FDOT costs for CEI services as a percentage of project cost have decreased over the past four years.
2. Analysis of the cost data indicates that Consultant costs for CEI services as a percentage of project cost have increased over the past four years.
3. Developing an understanding of the source of variability in the CEI cost from project to project.

## **IMPLEMENTATION PLAN**

### **Part I Technical Summary**

A technical summary has been prepared and included within this report.

### **Part II Technology Transfer Plan**

The recommendation is for the FDOT to form a Task Group to review the results of this research and to oversee implementation within the FDOT. The Principal Investigator for this study is available to participate in this activity. Within one year, the Task Group should identify specific changes in procedures and initiate their implementation on a trial basis. Based upon the results of the trials, final implementation should be accomplished in year two.

### **Part III Implementation Test**

The Task Group should report quarterly on the status of its work to the Secretary of Transportation or his representative.

Cost savings because of implementation should be accounted and reported.

## Appendix A.

1. Does your organization utilize consultants to perform construction engineering and inspection (CEI) services on your construction projects?
  - Yes (Please complete questions 2 –11.)
  - No (If your answer is no, please answer question 2 and return the survey. Thank you for your time and effort.)

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2. For projects in which you perform the CEI functions with your own DOT personnel, what is the estimated average CEI cost as a percentage of total construction contract cost?

3. For projects in which your consultants perform CEI functions, what is the estimated average CEI cost as a percentage of total construction contract cost?

(Questions 2 and 3: If this information is not available for your entire program, please check the costs of a few representative projects.)

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4. In what year did you begin using CEI consultants?

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5. When you utilize consultants for CEI services, what is their typical scope of work? Please check the appropriate items.

- Personnel Staffing Only:** Providing Temporary Technical Personnel and Equipment at an Hourly Rate
- Comprehensive Management:** Responsible for Providing the Same Administration and Inspection Functions Normally Performed by the State DOT
- Sampling and Testing:** Responsible for Complete Sampling and Testing Functions

6. If you use consultants to perform CEI services, what is the average salary rate by class?

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## Appendix B.

	Question 9
States	Who oversees?
Alabama	
Alaska	Engineer in Charge
Arizona	District Manager
Arkansas	DCE & SCE
California	
Canada	Project Managers
Colorado	Resident Engineer or materials Engineer
Connecticut	Project Engineer & above
Delaware	DCE or District Construction Manager
Florida	Construction Management
Georgia	DCE
Hawaii	Resident Engineer
Idaho	Resident Engineer
Illinois	State Resident Engineer
Indiana	District engineer
Iowa	Res Con Eng & DCE
Kansas	Construction Eng
Kentucky	yes
Louisiana	DCE
Maine	Construction Eng
Maryland	District Office and Office of Construction
Massachusetts	Construction Division
Michigan	District Engineer
Minnesota	District Rep
Mississippi	Eng approved by Chief Eng
Missouri	
Montana	DCE
Nebraska	
Nevada	Contract Admin Manager
New Hampshire	Project Contract Admin
New Jersey	Reg Consult Field Manager or Res Eng
New Mexico	DCE or designee
New York	Engineer in Charge
North Carolina	
North Dakota	District Engineer or Representative
Ohio	DCE
Oklahoma	DCE
Oregon	
Pennsylvania	DOT Project Engineer or Resident Engineer
Puerto Rico	Director of Construction Area
Rhode Island	
South Carolina	District engineer
South Dakota	
Tennessee	Proj Eng, Reg. Const. And H Q const.
Texas	
USVI	
Utah	Seprate CEI supervisor
Vermont	Resident Engineer
Virginia	District Project Engineer
Washington	
West Virginia	DCE
Wisconsin	Project Managers
Wyoming	

## Appendix C.

Work Mix	Year	Average CEI	Average FDOT	Delta	CEI	DOT
12	90					
12	91					
12	92		\$ 425.00		0	1
12	93		\$ 500.00		0	1
12	94				0	0
12	95				0	1
12	96	\$ 679.00	\$ 566.00	113.00	1	11
12	97	\$ 1,512.00	\$ 754.00	758.00	18	24
12	98	\$ 1,477.00	\$ 701.00	776.00	21	33
12	99	\$ 2,073.00	\$ 357.00	1,716.00	5	6
24	90		\$ 429.00		0	1
24	91		\$ 623.00		0	4
24	92		\$ 629.00		0	5
24	93	\$ 266.00	\$ 363.00	(97.00)	1	5
24	94		\$ 447.00		0	4
24	95	\$ 792.00	\$ 163.00	629.00	4	7
24	96	\$ 402.00	\$ 302.00	100.00	3	21
24	97	\$ 1,353.00	\$ 400.00	953.00	4	24
24	98	\$ 1,088.00	\$ 604.00	484.00	14	40
24	99	\$ 1,803.00	\$ 304.00	1,499.00	5	32
46	90					
46	91					
46	92					
46	93					
46	94					
46	95	\$ 182.00	\$ 204.00	(22.00)	3	2
46	96	\$ 185.00	\$ 162.00	23.00	7	1
46	97		\$ 213.00		0	2
46	98					
46	99					
119	90		\$ 269.00		0	1
119	91		\$ 410.00		0	2
119	92				0	0
119	93		\$ 726.00		0	5
119	94		\$ 470.00		0	1
119	95		\$ 296.00		0	4
119	96		\$ 333.00		0	7
119	97	\$ 988.00	\$ 576.00	412.00	2	9
119	98	\$ 906.00	\$ 545.00	361.00	2	10
119	99		\$ 518.00		0	9
121	90		\$ 914.00		0	1
121	91				0	0
121	92				0	0

Work Mix	Year	Average CEI	Average FDOT	Delta	CEI	DOT
121	93				0	0
121	94				0	0
121	95				0	0
121	96				0	0
121	97	\$ 2,028.00	\$ 982.00	\$1,046.00	3	2
121	98	\$ 1,966.00	\$ 1,082.00	\$ 884.00	5	2
121	99				0	0
213	90					
213	91					
213	92					
213	93					
213	94					
213	95					
213	96					
213	97	\$ 2,032.00	\$ 575.00	\$1,457.00	9	2
213	98	\$ 1,440.00	\$ 1,004.00	\$ 436.00	6	4
213	99	\$ 1,988.00			1	0
220	90					
220	91					
220	92					
220	93					
220	94					
220	95					
220	96					
220	97	\$ 1,685.00	\$ 704.00	\$ 981.00	1	5
220	98	\$ 1,855.00	\$ 769.00	\$1,086.00	3	10
220	99	\$ 1,988.00			1	0
421	90					
421	91					
421	92					
421	93					
421	94		\$ 664.00			1
421	95					
421	96					
421	97	\$ 1,091.00	\$ 392.00	\$ 699.00	2	2
421	98	\$ 811.00	\$ 473.00	\$ 338.00	5	8
421	99	\$ 1,265.00			2	
429	90		\$ 672.00			4
429	91		\$ 694.00			9
429	92	\$ 1,661.00	\$ 458.00	\$1,203.00	1	11
429	93		\$ 327.00			12
429	94	\$ 970.00	\$ 412.00	\$ 558.00	2	13
429	95	\$ 894.00	\$ 291.00	\$ 603.00	6	19
429	96	\$ 920.00	\$ 608.00	\$ 312.00	3	6
429	97	\$ 1,535.00	\$ 169.00	\$1,366.00	4	11
429	98	\$ 759.00	\$ 228.00	\$ 531.00	1	1

Work Mix	Year	Average CEI	Average FDOT	Delta	CEI	DOT
429	99					
549	90					
549	91					
549	92		\$ 1,376.00			1
549	93		\$ 524.00			5
549	94		\$ 327.00			6
549	95		\$ 233.00			7
549	96		\$ 337.00			7
549	97	\$ 623.00	\$ 545.00	\$ 78.00	4	7
549	98		\$ 471.00			15
549	99		\$ 456.00			5
9917	90					
9917	91					
9917	92					
9917	93					
9917	94					
9917	95					
9917	96		\$ 523.00			1
9917	97		\$ 509.00		3	4
9917	98	\$ 824.00	\$ 734.00	\$ 90.00	2	6
9917	99	\$ 814.00	\$ 376.00	\$ 438.00	2	1
9924	90		\$ 761.00			3
9924	91		\$ 489.00			2
9924	92		\$ 502.00			10
9924	93		\$ 485.00			8
9924	94		\$ 259.00			6
9924	95	\$ 521.00	\$ 247.00	\$ 274.00	1	12
9924	96		\$ 167.00			14
9924	97	\$ 934.00	\$ 241.00	\$ 693.00	4	31
9924	98	\$ 1,129.00	\$ 264.00	\$ 865.00	3	14
9924	99	\$ 1,022.00	\$ 126.00	\$ 896.00	4	10