Final Evaluation of the Florida Department of Transportation's Pilot Design/Build Program

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Interest in design/build as an alternative contracting method is growing. Results of a pilot design/build program undertaken by the Florida Department of Transportation are presented. Project performance results were measured and compared with non–design/build projects during the same period. Significant improvements in project performance were realized. Results of a survey of all participants are included. Final evaluation and suggestions for improvement are given.

In the late 1980s the design/build contracting system gained increased attention from many construction contracting organizations. Construction contracting authorities began to examine new contracting methods that departed from the traditional low bid model. The state of Florida also recognized the potential value of a design/build contracting system to its public works construction program. Consequently, on June 30, 1987, the Florida legislature passed a new law authorizing the Florida Department of Transportation (FDOT) to undertake a trial design/build program. The pilot program was to consist of projects accomplished by a combined design and construction contractor. The program was given a funding limit of $50 million.

After a considerable amount of study, FDOT put together a design/build contracting program, hoping to significantly improve upon its traditional non–design/build systems. Eleven projects covering a variety of construction categories were eventually awarded as design/build projects. The program appeared to be successful. However, as with many new concepts, the design/build program was controversial. The Florida Transportation Builders Association, Inc., a road builders contractor organization, strongly opposed the program. Political debate appeared to make the future of Florida's design/build program uncertain. Clearly, there was a need for an objective evaluation of the program results on the basis of quantifiable measures.

As a result, FDOT employed the University of Florida to conduct a study of the design/build pilot program (*1*). The study was to provide an impartial evaluation of the trial program and to suggest improvements. The results of this evaluation provide an interesting comparison of design/build project performance with that of the traditional low bid project.

Historically, a great deal of information in the form of opinion exists concerning design/build as an alternative contracting procedure. Examination of these reports provides little quantitative information on project performance.

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A study done by the Transportation Corridor Agencies listed several potential benefits of the design/build process: not-to-exceed pricing, transfer of liability, construction cost savings, and design-construction time savings (*2*). However, another study administered by the National Cooperative Highway Research Program failed to find any clear documentation to substantiate time and cost savings resulting from design/build (*3*). Furthermore, design/build quality was found to be closer to minimum requirements than conventional contracting methods.

In spite of the controversy and lack of quantifiable data, national attention is focusing on design/build as an innovative contracting method (*4*). A Transportation Research Board task force is currently attempting to encourage experimentation and demonstrations with this system (T. Deen, unpublished data). Although the Federal Highway Administration does not yet participate in design/build projects, it has begun to realize the need for innovative and improved contracting practices.

FDOT DESIGN/BUILD MODEL

The basic concept of design/build is that both the design task and the construction task are assigned to a single contractor. Combination of design and construction responsibility suggests several advantages. For example, construction knowledge and expertise should become a part of the design (*5*). Administration of the work may be easier when only one entity must be dealt with. Time savings may be realized, particularly if the construction can begin before completion of the design.

Although all design/build programs share the basic concept of combining design and construction, there are many variations in the method used to select the design/build contractor. In the U.S. Navy Newport design/build model, design/build contractors submit a price proposal before any design submission. Award is made solely on the basis of low bid. Following award, a complete design must be submitted for approval before commencing construction (*6*).

Other agencies, including the U.S. Air Force and the U.S. Army Corps of Engineers, have used a two-step design/build system (*7*). In this case design/build contractors first submit their proposed designs. A short list of acceptable designs is then prepared. The short-listed contractors are then invited to submit a price proposal. Final award is based on low bid.

FDOT has developed a modified one-step procedure, which includes several unique features. Prequalification is done only at one stage, and teams of both contractor and consultant are selected instead of individual selections being made. Before advertisement, a design criteria package is prepared by FDOT, and prospective design/build teams are required to submit a letter of interest setting forth their prequalifications. Applicants are evaluated on the basis of their experience and available resources. A certification and technical review committee (CTRC) determines the relative ability of each applicant to perform the required services and assigns a score. A short list of qualified applicants is then prepared.

The short-listed design/build firms are invited to submit both a technical and a price proposal. The technical proposal includes design and time information. Each proposal is evaluated by CTRC, and scores are assigned for the design and time elements. The total score includes points for the following categories: management and organizational qualifications, design, and project schedule.

The weight assigned to each of these categories varies from project to project. For example, design may be considered a more important element for a bridge project than for a resurfacing project. The proposed price is divided by the total score to obtain adjusted score. Final award is made to the bidder with the lowest adjusted score.

FDOT's design/build model contains three features that distinguish it from other design/build systems. First, the contractor's qualification score is made a part of the total score on the basis of which final award is made. Second, the contractor is required to propose a time for the project, which is a major factor in calculating the final score. Finally, the contractor is required to perform construction engineering and inspection for the project. The cost of these services is to be included in the cost proposal. Figure 1 shows the FDOT design/build selection process.

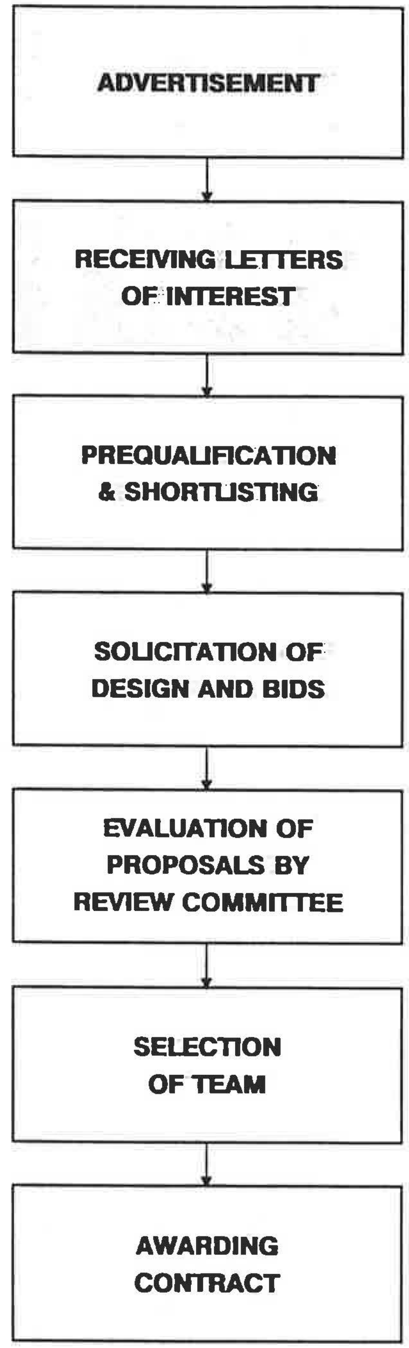

FIGURE 1 FDOT design/build procurement procedure.

COST PERFORMANCE EVALUATION

One troublesome aspect of evaluating design/build performance is that it is often difficult to directly compare design/build with non–design/build project performance. If a project has been accomplished as a design/build project, its performance can certainly be measured. However, what would have been the project performance if the same job had been accomplished as a traditional low bid project? Identical projects do not exist. Many variables, such as the contractor, the work season, and location, have a significant effect on project performance. Direct comparisons are in most cases not possible.

The approach used in this study has been to compare the mean performance measures of the design/build projects with the statistical mean performance measures of non–design/build projects. As far as possible, comparisons have been made using similar project categories such as size, type, and performance period. An attempt has been made to determine whether the average design/build results were significantly different from the average results obtained on non–design/build projects. Finally, if a difference is indicated, quantification of that difference has been attempted.

Table 1 presents the projects that have been accomplished under the FDOT design/build program. Original bid amounts are given in Column 4, and original bid times are given in Column 5.

FDOT uses a highly standardized cost estimating system to develop prebid estimates of cost. The estimating procedure accesses a data base of previously bid work activity unit prices. Estimates are prepared using quantities taken off the final design drawings and appropriate unit prices. Costs are adjusted for a variety of factors, including project location, time frame, and size.

Using the same estimating procedures as for traditional non–design/build projects, the FDOT estimating section pre-

TABLE 1 Design/Build Pilot Program Projects

Project (1)	Location (2)	Type of Project (3)	Bid Amounts (dollars) (4)	Bid Construction Time (days) (5)
Resurfacing SR 776 01050-3519	Charlotte County	Resurfacing	1,081,776	161
Resurfacing SR 13 78070-3519	St. Johns County	Resurfacing	1,785,000	240
Resurfacing SR 71 51020-3517	Gulf County	Resurfacing	1,385,765	180
Resurfacing SR 7 86100-3587	Broward County	Resurfacing	1,413,273	239
Resurfacing SR 91 97871-3322	Dade County	Resurfacing	2,912,936	210
Resurfacing SR 15 75080-3529	Orange County	Resurfacing	992,844	150
Bay Bridge 49040-3501 & 59010-3516	Ochlockonee County	Bridge	12,210,000	609
Turnpike FEC R/R 97940-3367	St. Lucie County	Bridge	1,888 206	540
Turnpike 97931-3310	Palm Beach County	Multilane	4,044,067	450
Const/Maint Office 11000-3511	Leesburg County	Building (FCO)	446,000	270
Turnpike Tolls Data Center 97931-3315	Palm Beach County	Building (FCO)	2,349,000	337

pared engineer's estimates of the design/build projects. Since final quantities are required, this type of estimate is normally prepared after the design is completed. Consequently, for the design/build projects the engineer's estimate could not be prepared until after the projects were awarded and the designs had been completed. Final quantities were generally not available until project completion. At the close of the study, quantities were available for seven of the design/build projects, and an FDOT engineer's estimate was generated for each. Budget figures were available for the projects that did not have an engineer's estimate. However, since the budgets were developed before design, they were not considered comparable with actual costs.

The engineer's estimate of cost was used as a baseline for establishing a cost comparison between the design/build projects and historical performance on non-design/build projects. FDOT maintains a historical data base of its engineer estimates compared with the low bids received. A review of these data provided an average difference between the FDOT engineer's estimate and the low bid. A summary of these data is presented in Table 2. It appears that the low bids received are somewhat below the engineer's estimates on the average.

Using this historical mean difference between the engineer's estimate and the low bid received, an expected low bid price was calculated for the design/build projects. Table 3 presents the adjustment of the engineer's estimated design/build project costs to an expected non-design/build low bid cost. Column 2 gives the engineer's estimate. Column 4 gives the expected low bid costs.

Since the design/build bid cost includes design, inspection, and construction, the non-design/build low bid cost had to be increased to include these costs. Estimates of design cost were developed from an analysis of 306 projects designed during the performance period of the design/build projects. Design cost on traditional projects averaged from 14 percent for projects costing less than $1 million to 6 percent for projects costing between $1 million and $10 million. The same procedure was used to develop an average historical construction engineering/inspection cost. Construction engineering/inspection costs were derived from an analysis of 395 projects performed during the design/build performance period. Table 4 summarizes FDOT's design costs and construction engineering/inspection costs.

These additional costs were added to the expected low bid

TABLE 2 Difference Between Low Bid and Engineer-Estimated Costs of FDOT Projects

Statistics (1)	Project Size Categories: Less than $100,000 (%) (2)	$100,000 to $250,000 (%) (3)	$250,000 to $500,000 (%) (4)	$500,000 to $1,000,000 (%) (5)	$1,000,000 to $3,000,000 (%) (6)	Greater than $3,000,000 (%) (7)
Mean	-14.7	- 4.0	- 6.1	-14.9	- 9.1	-10.3
Minimum	-46.3	-39.7	-27.6	-44.5	-38.1	-30.6
Maximum	26.3	23.1	16.9	28.0	26.4	15.9
Average Above	8.9	8.5	9.4	29.1	9.0	7.0
Average Below	-17.8	-13.0	-12.9	-17.7	-13.2	-14.4
Total Observations	52	33	36	34	59	53

NOTE: Based on the summary of FDOT statistics for 1990.

TABLE 3 Adjustment of Engineer's Estimated Design/Build Project Cost to Probable Non–Design/Build Low Bid Cost

Project (1)	Engineer's Estimate (Construction Cost Only) (dollars) (2)	NDB Probable Low Bid: Adjustment Factor (%) (3)	NDB Probable Low Bid: Construction Cost (dollars) (4)	Design and Inspection Adjustment Factor (%) (5)	Probable NDB Low Bid Total Cost (Including design and inspection costs) (dollars) (6)
Resurfacing SR 776 01050-3519	979,786	-14.9	833,798	+25.38	1,045,416
Resurfacing SR 13 78070-3519	--	--	--	--	--
Resurfacing SR 71 51020-3517	1,112,454	- 9.1	1,011,221	+25.38	1,267,869
Resurfacing SR 7 86100-3587	1,332,729	- 9.1	1,211,451	+25.38	1,518,917
Resurfacing SR 91 97871-3322	2,935,278	- 9.1	2,668,168	+21.3	3,236,488
Resurfacing SR 15 75080-3529	620,105	-14.9	563,675	+25.38	706,736
Bay Bridge 49040-3501 & 59010-3516	11,452,183	-10.3	10,272,608	+15.3	11,844,317
Turnpike FEC R/R 97940-3367	--	--	--	--	--
Turnpike 97931-3310	--	--	--	--	--
Const/Maint Office 11000-3511	390,729	- 6.1	366,894	+31.04	480,778
Turnpike Tolls Data Center 97931-3315	--	--	--	--	--

TABLE 4 Design, Construction Engineering, and Inspection Costs as Percentage of Total Project Costs for FDOT Projects

Project Size Categories (dollars) (1)	Design Cost (%) (2)	Construction Engineering and Inspection Cost (%) (3)
$250,000 to $500,000	17.04	14.0
$500,000 to $2,500,000	11.88	13.5
$2,500,000 to $10,000,000	12.0	9.3
$10,000,000 to $15,000,000	9.3	6.0

NOTE: 1) CEI costs (3) based on job charges for projects completed in fiscal years 88/89 & 89/90.
2) Design costs (2) based on database sample of projects completed in fiscal years 88/89 & 89/90.

cost to obtain a probable non–design/build low bid total cost. Column 6 in Table 3 gives the probable non–design/build total cost for the design/build projects.

A comparison of the actual design/build total cost is presented in Table 5. Three of the seven projects had a design/build cost greater than the estimated non–design/build cost. Four of the projects had a design/build cost less than the estimated non–design/build cost. The mean difference for all seven projects was a design/build cost 4.59 percent greater than an estimated non–design/build cost. However, one project appears to be an outlier in the data set. Resurfacing SR-15 resulted in a design/build cost 40.5 percent greater than the estimated non–design/build cost. Discussions with the estimators and with the project participants have failed to resolve this difference. The source of the variation remains unexplained. However, the investigation detected no evidence indicating that the additional cost resulted from the design/build contracting system.

If the project that had a 40.5 percent cost difference is omitted, the average design/build costs is 1.39 percent less than the estimated non–design/build costs. Considering the data variability and the outlying data point, the results do not indicate a significant difference in total project cost between design/build and non–design/build projects. This analysis does not consider any possible differences in road user cost. Only direct construction, design, and inspection costs have been considered.

Figure 2 presents the results of a statistical hypothesis test to test the hypothesis that the mean difference between design/build cost and the probable non–design/build cost is equal to 0. The hypothesis could not be rejected at the 95 percent significance level (*8*).

TIME PERFORMANCE EVALUATION

The procedure used to evaluate time performance was to compare the actual design/build project time with an estimated non–design/build project time. This involved developing an estimate of the project time that would have been required if the project had been performed as a non–design/build project. Since the design/build proposals include both design and construction tasks, an allowance for design time was added to the non–design/build construction time estimate.

FDOT develops a normal construction time for each non–design/build project. This time is determined by applying normal production rates to the project activity quantities. For the traditional non–design/build projects, the normal time typically becomes the specified contract duration.

However, as might be expected, actual performance times vary significantly from the specified original normal times. An analysis of 823 non–design/build projects performed during the design/build program period indicated that the mean difference between the original and the actual times was 14.7 percent. That is, on the average, the actual construction time required was 14.7 percent more than originally allocated. The original times do not include allowances for weather or other legitimate changes to the contract.

An FDOT normal construction time was developed for each of the design/build projects. It was adjusted by the 14.7 percent mean difference found for non–design/build projects. Table 6 gives the adjustment of the normal construction time to probable non–design/build actual construction time. Column 4 in Table 6 gives the estimated non–design/build construction times.

Table 7 compares the design/build actual construction time with the estimated non–design/build construction times. Nine of the 11 design/build projects produced actual construction times that were less than the estimated time required to perform the project as a non–design/build project. Two of the design/build projects required more time than estimated for performing the projects as non–design/build projects. The mean of the design/build comparison was 21.1 percent. That is, on the average, the design/build construction time was 21.1 percent less than the predicted non–design/build construction time.

With regard to design time, the design/build actual design procurement time was compared with the normal time allotted by FDOT for non–design/build design procurement. Data were not available concerning variances in actual non–design/build design times compared with the normal times set for design procurement. However, officials at FDOT believe that the actual design times vary very little from the normal times.

TABLE 5 Comparison of Design/Build and Probable Non-Design/Build Costs

Project (1)	DB Bid Amount (dollars) (2)	Probable NDB Total Amount (dollars) (3)	Difference of DB & NDB Amount (dollars) (4)	Difference of DB & NDB Percent (%) (5)	Mean Difference (%) (6)
Resurfacing SR 776 01050-3519	1,081,776	1,045,416	36,360	3.48	
Resurfacing SR 13 78070-3519	1,785,000	--	--	--	
Resurfacing SR 71 51020-3517	1,385,765	1,267,869	117,896	9.3	
Resurfacing SR 7 86100-3587	1,413,273	1,518,917	-105,644	-6.95	
Resurfacing SR 91 97871-3322	2,912,936	3,236,488	-323,552	-10.0	4.59
Resurfacing SR 15 75080-3529	992,844	706,736	286,108	40.5	
Bay Bridge 49040-3501 & 59010-3516	12,210,000	11,844,317	365,683	3.08	
Turnpike FEC R/R 97940-3367	1,888,206	--	--	--	
Turnpike 97931-3310	4,044,067	--	--	--	
Const/Maint Office 11000-3511	446,000	480,778	-34,778	-7.23	
Turnpike Tolls Data Center 97931-3315	2,349,000	--	--	--	
		TOTAL DIFFERENCE	342,073	32.18	

Table 8 compares the actual design/build design procurement times with the times normally required for non-design/build design procurement. The design/build designs were procured in considerably less time than would have been required under the normal non-design/build system. On the average, the design/build designs were acquired in 54.0 percent less time than required for normal non-design/build projects.

Table 9 compares total project time for the design/build projects and predicted non-design/build projects. All of the design/build projects performed better than the expected non-design/build results. On the average, the total design/build project time was 35.7 percent less than predicted for performing the projects as traditional non-design/build projects.

A small sample t-test was performed to verify the existence of a statistically significant difference in means between the construction time results on the design/build projects and the non-design/build projects. The results of this statistical analysis are shown in Figure 3. The design/build construction time results were confirmed to be statistically greater than the non-design/build results at a 95 percent significant level. The lower bound of the 95 percent confidence interval is calculated to be 18.0 percent. In other words, the statistical analysis indicates that at a 95 percent level of significance the design/build construction time results were at least 18.0 percent better than the average non-design/build results.

SURVEY OF DESIGN/BUILD PARTICIPANTS

It was believed that quantitative evaluations may not tell the complete story. Therefore, participants in the FDOT design/build pilot program were surveyed to obtain additional input. The participant list included design consultant partners and road builder contractor partners of all design/build teams that had submitted letters of interest in response to FDOT design/build advertisements. This includes both successful and un-

OBJECTIVE:	To test if the mean percentage difference of Design/Build low bid and probable Non-Design/Build total cost is zero.
STATISTICAL DATA:	$\bar{y} = 4.59$ $n = 7$ $s = 17.32$ df = 6 (degrees of freedom = 7-1)
TEST:	H_o: $\mu = 0$ H_a: $\mu \neq 0$ TS: $t = \dfrac{\bar{y} - \mu_o}{s/\sqrt{n}} = 0.7$ RR: $t_{\alpha/2} = 2.447$ (for $\alpha = 0.05$ & df = 6)
RESULT:	Since 0.7 < 2.447, therefore do not reject null hypothesis.
CONCLUSION:	At 95% confidence level it can not be concluded that mean percentage difference is not zero.
CONFIDENCE INTERVAL:	At 95% level Min = -11.43, Max = 20.61.

FIGURE 2 Hypothesis testing for design/build costs.

TABLE 6 Adjustment of Normal Construction Time to Probable Non–Design/Build Actual Construction Time

Project (1)	Normal Construction Time (days) (2)	NDB Adjustment Factor (%) (3)	Probable NDB Actual Construction Time (days) (4)
Resurfacing SR 776 01050-3519	270	14.7	310
Resurfacing SR 13 78070-3519	270	14.7	310
Resurfacing SR 71 51020-3517	270	14.7	310
Resurfacing SR 7 86100-3587	270	14.7	310
Resurfacing SR 91 97871-3322	365	14.7	419
Resurfacing SR 15 75080-3529	270	14.7	310
Bay Bridge 49040-3501 & 59010-3516	1,000	14.7	1,147
Turnpike FEC R/R 97940-3367	365	14.7	419
Turnpike 97931-3310	365	14.7	419
Const/Maint Office 11000-3511	365	14.7	419
Turnpike Tolls Data Center 97931-3315	420	14.7	482

TABLE 7 Comparison of Design/Build Actual Construction Time with Probable Non–Design/Build Actual Construction Time

Project (1)	DB Actual Construction Time (days) (2)	Probable NDB Actual Construction Time (days) (3)	DB and NDB Time Difference (days) (4)	DB and NDB Time Difference (%) (5)	Mean Difference (%) (6)
Resurfacing SR 776 01050-3519	154	310	-156	-50.3	
Resurfacing SR 13 78070-3519	279	310	-31	-10.0	
Resurfacing SR 71 51020-3517	200	310	-110	-35.5	
Resurfacing SR 7 86100-3587	225	310	-85	-27.4	
Resurfacing SR 91 97871-3322	218	419	-201	-47.9	-21.1
Resurfacing SR 15 75080-3529	229	310	-81	-26.1	
Bay Bridge 49040-3501 & 59010-3516	536	1,147	-611	-53.3	
Turnpike FEC R/R 97940-3367	570	419	151	36.0	
Turnpike 97931-3310	527	419	108	25.8	
Const/Maint Office 11000-3511	253	419	-166	-39.6	
Turnpike Tolls Data Center 97931-3315	462	482	-20	-4.1	
	TOTAL DIFFERENCE		-1,202	-232.4	

successful proposers. A total of 74 participants were surveyed, and 32 responses were obtained.

A summary of the survey data is shown in Figure 4. The results of questions covering the most significant issues are as follows:

1. Fifty-three percent of the respondents found the design criteria furnished by FDOT to be satisfactory. Thirty-seven percent found it to be not sufficient. Ten percent thought it was overly restrictive.
2. Seventy-five percent of the respondents found FDOT's evaluation and scoring procedure to be appropriate.
3. The respondents ranked the project categories in terms of suitability for the design/build method as follows, in order of highest to lowest suitability: building structures, bridges, resurfacing, and multilane.
4. Ninety-four percent of the respondents believed that FDOT should subsidize a portion of the design cost for the unsuccessful short-list participants.
5. Sixty-six percent of the respondents found that the design/build system resulted in reduced construction time.
6. Seventy-two percent of the respondents found setting their own construction time to be beneficial.
7. Seventy-four percent of the respondents indicated that FDOT's design/build program should be continued with changes. Ten percent indicated that it should be continued as is. Sixteen percent believed that it should be discontinued.

This input from the design/build participants appears to indicate a generally favorable response to the program. Very small differences in responses could be detected between design consultant and contractor participants. For example, 73

TABLE 8 Comparison of Normal Design/Procurement Time with Design/Build Design/ Procurement Time

Project (1)	DB Design/ Procure-ment Time (days) (2)	Normal Design/ Procure-ment Time (days) (3)	Design/Procurement Time Difference (days) (4)	Design/Procurement Time Difference (%) (5)	Mean Difference (%) (6)
Resurfacing SR 776 01050-3519	134	300	-166	-55.3	
Resurfacing SR 13 78070-3519	133	300	-167	-55.7	
Resurfacing SR 71 51020-3517	132	300	-168	-56.0	
Resurfacing SR 7 86100-3587	138	300	-162	-54.0	
Resurfacing SR 91 97871-3322	134	300	-166	-55.3	-54.0
Resurfacing SR 15 75080-3529	132	300	-168	-56.0	
Bay Bridge 49040-3501 & 59010-3516	229	420	-191	-45.5	
Turnpike FEC R/R 97940-3367	139	300	-161	-53.7	
Turnpike 97931-3310	146	300	-154	-51.3	
Const/Maint Office 11000-3511	127	300	-173	-57.7	
Turnpike Tolls Data Center 97931-3315	138	300	-162	-54.0	
TOTAL DIFFERENCE			-1,838	-594.5	

percent of the contractors, who are usually uncomfortable with subjective award procedures, found the evaluation method appropriate. Seventy-seven percent of the designers answered the same question positively.

SUMMARY AND CONCLUSIONS

FDOT has completed a trial design/build program consisting of 11 projects with a total contract value of $30,508,867. The project performance results for these trial design/build projects have been measured and compared with the average performance obtained on FDOT's non–design/build projects during the same period.

An analysis of the cost performance information indicated that the average design/build direct cost was 4.59 percent greater than the average non–design/build cost. However, statistical analysis of the data failed to confirm this difference in means. Because of the small sample size (seven) and the data variability, the result of the direct cost comparison is inconclusive.

Comparison of project time performance results provided a more definite indication. The average design/build construction time was 21.1 percent less than the average for non–design/build projects. Statistical analysis indicated with a 95 percent degree of certainty that the design/build average construction time was at least 18.0 percent less than the non–design/build average construction time. Actual design/build design procurement times were also considerably less than the normal design procurement time for non–design/build projects. The average design/build design time was 54 percent less than the normal time allocated for non–design/build design procurement. The savings in project performance time means that for the 11 design/build projects an additional 3,040 project days would probably have been required if the projects

TABLE 9 Comparison of Total Design/Build Time with Probable Total Non–Design/Build Time

Project (1)	Total DB Time (days) (2)	Total Probable NDB Time (days) (3)	Total Project Time: Difference (days) (4)	Total Project Time: Difference (%) (5)	Mean Difference (%) (6)
Resurfacing SR 776 01050-3519	288	610	-322	-52.8	
Resurfacing SR 13 78070-3519	412	610	-198	-32.5	
Resurfacing SR 71 51020-3517	332	610	-278	-45.6	
Resurfacing SR 7 86100-3587	363	610	-247	-40.5	
Resurfacing SR 91 97871-3322	352	719	-367	-51.0	-35.7
Resurfacing SR 15 75080-3529	361	610	-249	-40.8	
Bay Bridge 49040-3501 & 59010-3516	765	1,567	-802	-51.2	
Turnpike FEC R/R 97940-3367	709	719	-10	-1.4	
Turnpike 97931-3310	673	719	-46	-6.4	
Const/Maint Office 11000-3511	380	719	-339	-47.1	
Turnpike Tolls Data Center 97931-3315	600	782	-182	-23.3	
TOTAL DIFFERENCE			-3,040	-392.6	

had been accomplished under the traditional non–design/build method.

The design/build projects also produced a significant reduction in after-bid changes to the contract. The design/build program projects had an average change amount of 4.09 percent. FDOT's non–design/build projects for 1990 had an average change amount of 8.78 percent. This improvement suggests enhanced constructibility and designer-constructor interaction.

A survey of participants suggested that the program was generally well received. The majority of respondents, including contractors, indicated that the design/build program should be continued. In spite of the subjective nature of the award evaluation procedure, a majority of respondents including contractors believed that the evaluation method was appropriate.

Do these dramatic improvements in performance result from the combining of the design and construction functions within a single contract entity? Probably not entirely. There may be other features of FDOT's design/build model that contributed to the program's success. Qualification standards have been maintained at a high level. Therefore, the qualified participants are exceptional contractors and designers. Better-than-average performance would appear to be expected. Inclusion of the project time as a major award scoring criterion certainly establishes an incentive to reduce performance time. Furthermore, the selection of the projects to be done as design/build may introduce some bias.

These considerations should not detract from the program's apparent success. FDOT's pilot program has demonstrated that design/build can produce improved project performance. Design/build is an important contracting alternative.

OBJECTIVE:	To test if the mean percentage difference of original construction time and actual construction time for Design/Build (DB) Projects is significantly greater than Non-Design/Build (NDB) Projects.
STATISTICAL DATA:	μ_o = 14.77 (population mean difference of NDB) $\bar{y}$ = 9.47 (sample mean of 11 DB projects) n = 11 (number of DB projects) s = 33.02 (standard deviation of difference) df = 10 (degrees of freedom = 11-1)
TEST:	H_o: $\mu = 14.77$ H_a: $\mu < 14.77$ TS: $t = \dfrac{\bar{y} - \mu_o}{s/\sqrt{n}} = -2.43$ RR: $t_\alpha = 1.812$ (for $\alpha = 0.05$ & df = 10)
RESULT:	Since $|-2.43| > 1.812$, therefore reject null hypothesis.
CONCLUSION:	At 95% confidence level it can be concluded that sample mean is significantly greater than the population mean.
LOWER BOUND:	Minimum = $t_\alpha s/\sqrt{n} = 18.04$

FIGURE 3 Hypothesis testing for design/build construction time.

1) The design criteria given to the DB Team was --

Satisfactory	Not Sufficient	Overly Restrictive
53%	37%	10%
(16)	(11)	(3)

2) The proposal evaluation procedures and scoring were --

Appropriate	Not Appropriate
75%	25%
(21)	(7)

3) Rate the various projects with regard to their suitability for the Design/Build Program --

	Building Structure	Bridges	Resurfacing	Multi-lane
Highly Suitable	48%	34%	29%	3%
	(14)	(11)	(9)	(1)
Suitable	34%	44%	29%	52%
	(10)	(14)	(9)	(16)
Not Suitable	18%	22%	42%	45%
	(5)	(7)	(13)	(14)

4) Should the FDOT subsidize a portion of the proposal preparation cost for those bidders who are short listed and submit technical proposals --

Yes	No
94%	6%
(30)	(2)

5) Did the Design/Build System give you added ability to reduce construction time --

Yes	No
66%	34%
(21)	(11)

6) Was setting your own project time a beneficial feature of the Design/Build System --

Yes	No
72%	28%
(23)	(9)

7) The Design/Build Program should be --

Continued as is	Continued with changes	Not continued
10%	74%	16%
(3)	(23)	(4)

FIGURE 4 Summary of survey of design/build participants.

A review of the results of FDOT's trial design/build program suggests several observations concerning design/build.

First, the need for establishing high qualification standards should be balanced with the need to maintain a competitive construction market. If participation in the program is overly restrictive, competition will suffer. In FDOT's model, it may be more appropriate to establish a minimum prequalification standard. Once qualification is determined, each bidder would be evaluated solely with regard to design, cost, and proposed time. This may provide a more level playing field for the competitors and allow room for the newer and less-experienced participant.

Some compensation should be considered for nonsuccessful participants to cover at least part of their design costs. Without this subsidy the smaller designer may be unable to risk losing the investment in design cost. Therefore, competition may eventually be limited to only a few large participants. A reduction in competition sooner or later results in higher costs.

More study should be given to the question of which project categories are most suitable for design/build. Projects providing an opportunity for design innovation and contractor input into design appear to be good candidates. Projects where there is little design flexibility, such as repaving, probably are not the best design/build projects.

Design/build by its very nature is a contracting method that imposes some degree of restriction on competition. Contractors and designers are forced to find opposing partners. Depending on the prequalification standards, participation may be limited. For these reasons its use should be limited. Therefore, it is particularly important that design/build be used on projects in which the optimum benefit can be achieved.

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REFERENCES

1. R. D. Ellis. *Evaluation of the FDOT Design/Build Program.* Final report. State study 99700-7543-010. Florida Department of Transportation, 1991.
2. G. Henk. *Design-Build.* Transportation Corridor Agencies, Costa Mesa, Calif., 1990.
3. Bergstrahl-Shaw-Newman, Inc. *Contracting Practices and Payment Procedures.* NCHRP 20-7 Task 23. National Cooperative Highway Research Program, National Research Council, Washington, D.C., 1984.
4. D. Brown. Editorial. *Highways and Heavy Construction,* Vol. 133, No. 13, Oct. 1990.
5. R. Buesing. *Design/Build Contract Management—Legislative Changes and Legal Issues.* Design Build Conference, Florida Department of Transportation, 1989.
6. V. Spaulding and S. Johnson. *Newport Design/Build.* Naval Facilities Engineering Command, Norfolk, Va., 1988.
7. G. Heery and C. Thompsen. *Bridging.* U.S. Air Force Engineering Service, Wright-Paterson AFB, Ohio, 1991.
8. L. Ott. *An Introduction to Statistical Methods and Data Analysis* (third edition). PWS-Kent Publishing Company, Boston, Mass., 1988.

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