PEER-REVIEWED PAPER

SELECTING DESIGN-BUILD: PUBLIC AND PRIVATE SECTOR OWNER ATTITUDES

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ABSTRACT: Modern owners of constructed facilities are increasingly investigating a variety of alternative procurement methods. These methods include design-build, turnkey, and construction management. To effectively service this market-driven expansion of project delivery strategies in the construction community, a fundamental understanding of owner attitudes is required. This paper discusses results of research conducted to address owners' attitudes toward one specific alternative contracting method, design-build. A tremendous growth in design-build and limited existence of documented research on owner's attitudes toward design-build necessitate a focus on this particular delivery strategy. Primary design-build selection factors identified and analyzed include establishing cost, reducing cost, establishing schedule, shortening duration, reducing claims, large project size/complexity, and constructability/innovation. Additionally, a comparison of private and public owner design-build attitudes is documented.

INTRODUCTION

Design-build is a procurement method where one entity or consortium is contractually responsible for both the design and construction of a project. Design-build is not a new concept. In centuries past, it was the only procurement method available. Its roots originate in the ancient "master builder" concept where responsibility for both design and construction resided with one person.

Design-build has been traced to ancient Mesopotamia, where the Code of Hammurabi (1800 B.C.) fixed absolute accountability upon master builders for both design and construction. In classical Greece, great temples, public buildings, and civil works were both designed and built by master builders. Enduring structures such as the Parthenon and Theater of Dionysis are testimony to this master builder process ("An introduction" 1994).

During the Renaissance, architecture and construction evolved as distinct professions and the presence of master-builders diminished. Project complexity increased during this era and the functional need for specialization in both design and construction was required (Twomey 1989).

As statutory and case law developed during the 1800s, the separation evolved from functional to legal. Courts determined that architects were only liable in cases of negligence as opposed to the strict liability that contractors faced. As these liabilities became defined, the "traditional" design-bid-build method of project delivery emerged as the primary procurement method (Natkin 1994).

Design-bid-build remained the procurement method of choice until the inflationary 1970s and the litigious 1980s encouraged owner organizations to reevaluate this standard method of project procurement. Subsequently, the use of project delivery methods such as design-build, turnkey, and construction management emerged as viable alternatives to the traditional design-bid-build method.

Design-build in particular has experienced extraordinary growth in recent years. Since 1986 there has been continued growth in design-build construction in terms of previous volume and as a percentage of total construction ("The top" 1994). Current projections suggest continued growth of design-build. The U.S. Department of Commerce predicts that design-build will account for half of all nonresidential construction by the year 2001 (Rosenbaum 1995).

An inevitable outcome of this growth is the increased entry into the market by both contractors and architect-engineers (A/Es) possessing little or no design-build experience. Additionally, such growth suggests an increase in owners selecting design-build for the first time. Continued success of the design-build method requires doc-

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umentation and dissemination of fundamental design-build knowledge to these new participants. Therefore, to enhance owner selection of appropriate projects and to provide appropriate design-build services, the A/E, construction communities, and owner communities must improve their understanding of owner attitudes toward selecting design-build as a preferred delivery method.

The present paper documents results of research conducted to gain insight into owner design-build selection attitudes. Specifically, it identifies the primary selection factors available to owners, discusses results of an extensive owner survey, and compares public and private selection considerations.

RESEARCH GOALS

To adequately assess owner attitudes toward design-build, two research goals were established. These goals are (1) to gain insight into owner design-build selection factors; and (2) to compare public and private owner design-build attitudes.

Although reasons why owners select design-build as a delivery strategy of choice abound, there has been no substantive research conducted that specifically addresses the issue (Booth 1995; Branca 1988; Cushman and Taub 1992; "Design-build in" 1992; "Experiences" 1993; Twomey 1989). In fact, a current perception in industry is that there is no one reason why owners select design-build ("Experiences" 1992). However, previous research by the writers suggests the existence of primary factors for selecting design-build (Molenaar 1995; Songer et al. 1994). Therefore, the first research goal included identifying primary selection criteria specific to design-build and surveying owners to quantify any priority among the criteria.

The second research goal manifests itself from the dramatic increase in public sector design-build in recent years. By nature, private and public sector project procurement mechanisms are quite distinct. Therefore, it was considered important to investigate differences in public and private attitudes for design-build selection. To pursue the two research goals an owner survey questionnaire was developed and administered.

DATA COLLECTION

A survey questionnaire was developed and distributed to 290 owner organizations. Owners with experience in at least one design-build project were qualified to respond. There was a total of 182 responses representing a 63% response rate. Of the 182 responses, 49 did not have the proper experience to respond and 25 responded incorrectly by ranking more than one factor the same. A final total of 108 responses qualified for analysis.

Of the 108 responses analyzed, 63% were owners from the public sector and 37% were from the private sector, as shown in Fig. 1(a). As shown in Fig. 1(b), 83% of the survey represents building construction, 14% represents industrial, and 3% represents heavy and highway.

The cumulative construction experience of the owners responding to the questionnaire was 1,683 projects totaling over $12.75 billion of construction. There is a combination of over 90 separate public agencies and private companies represented.

Data collection focused on identifying owner design-build selection factors and determining associated priority rankings. An exhaustive literature search produced seven design-build selection factors for consideration. These criteria are illustrated in Table 1. Each factor is discussed next.

Establish Cost

Some owners choose design-build to secure a fixed construction cost. By allowing one entity total control over design, scope, and budget, there is less opportunity for scope-related change orders. Additionally, improved relations among A/Es and contractors reduce liability issues associated with increasing project cost. In the case of the Herald Washington Library Center in Chicago, Ill., the design-build approach was selected to guarantee the cost for the project ("Design/build competition" 1988).

Reduce Cost

Although very little empirical data exist that conclude the specific amount of cost savings produced through design-build, there is sound reasoning for an overall cost reduction. This cost reduction stems from two main components, the shortening of project duration and the introduction of the contractor's knowledge into the design (see the forthcoming Reduce Schedule and Constructability/Innovation sections).

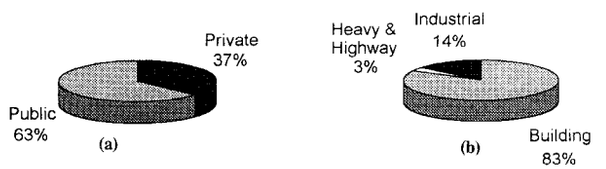

FIG. 1. Survey Population Characteristics: (a) Sector Type; (b) Construction Type

TABLE 1. Design-Build Selection Factors and Definitions

Selection factor (1)	Definition (2)
Establish cost	Secure a project cost before the start of detailed design
Reduce cost	Decrease the overall project cost as compared to other procurement methods (design-bid-build, construction management, etc.)
Establish schedule	Secure a project schedule before the start of detailed design
Shorten duration	Decrease the overall project completion time as compared to other procurement methods (design-bid-build, construction management, etc.)
Reduce claims	Decrease litigation due to separate design and construction entities
Large project size complexity	The project's shear magnitude is too complex to be managed through multiple contracts
Constructability/ innovation	Introduce construction knowledge into design early in the process

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Establish Schedule

For the same reasons why some owners choose design-build to establish cost, it can and may be chosen to establish a fixed schedule. A majority of the schedule growth in the traditional method stems from communication problems between the A/E and the contractor (i.e., requests for information, design errors, design omissions, and so forth). By allocating responsibility to one entity, these issues are minimized.

Reduce Schedule

Design-build promotes schedule reduction. Communication is greatly improved when design and construction are under one contract. This results in reduced design and construction cycle times and encourages fast-tracking.

Reduce Claims

Implicit in the design-build process is an owner's shelter from liability. The A/E does not perform as an agent of the owner. Design errors and omissions are solely the responsibility of the design-builder. Design-build is not a magic curve for the construction industry's litigation problems, but it does inherently promote a nonadversarial relationship between the designer and builder.

Large Project Size/Complexity

Dealing with one entity reduces administrative burden. Many owners do not have the staff members or experience to manage the traditional triad of owner-designer-builder. Taking one player out of the game lessens managerial tasks on large or complex construction projects. It should be noted, however, that the owner's involvement early in the process is often increased (Molenaar 1995) and there is a loss of the A/E as an indepenent professional (''Design-build in'' 1992).

Design/Build Selection Factors

This section seeks to answer the question:

- Why do public sector owners select the design/build procurement method?

Based on your experience, please rank (1 through 7) the design/build selection factors (1 being most important).

Design/Build Selection Factors	Rank
A. *Establish Cost* - Secure a project cost before the start of detailed design.	____
B. *Reduce Cost* - Decrease the overall project cost as compared to other procurement methods (design-bid-build, construction management, etc.)	____
C. *Establish Schedule* - Secure a project schedule before the start of detailed design.	____
D. *Shorten Duration* - Decrease the overall project completion time as compared to other procurement methods (design-bid-build, construction management, etc.)	____
E. *Reduce Claims* - Decrease litigation due to separate design and construction entities.	____
F. *Large Project Size/Complexity* - The project's shear magnitude is too complex to be managed through multiple contracts.	____
G. *Constructablity/Innovation* - Introduce construction knowledge into design early in the process.	____

Comments

_____

_____

_____

FIG. 2. Design-Build Survey

Constructability/Innovation

Inherent in the design-build process is early involvement of the contractor. Interjecting contractor knowledge early into the design fosters creative design and construction solutions. If used correctly, design-build promotes constructability and innovation in the same manner as a value engineering plan.

Notably missing from the list is the concept that owners select design-build because it establishes a single source of responsibility. This is the definition of design-build and encompasses all of the selection factors. It was determined early on not to use ''single source'' as a reason for selecting design-build because it is too general and it would not offer insight into the true motivation for choosing design-build.

These seven factors were used as the list of possible reasons to select design-build in the survey questionnaire. Owners were asked to assign the most important selection factor a ''1'' and to assign the least important selection factor a ''7.'' The questionnaire is illustrated in Fig. 2.

STUDY RESULTS

Design-Build Selection Factors

Table 2 summarizes the results of the survey whereby priority rankings of the seven selection criteria are identified. The selection factors are sorted by mean score. Rankings for median score are shown as well. While mean and median rankings agree, the mean score offers more insight into the relationship of the ranking. For example, there is only one number 3 ranking by mean score, but there are four number 3 rankings by median score. The minimum and maximum scores are also shown.

The individual rankings of the seven success criteria yield a mean score that can be used to achieve an overall ranking. This overall ranking is shown graphically in Fig. 3. Note that lower mean scores indicate greater importance for selection.

Fig. 3 illustrates that there is one primary reason why

TABLE 2. Survey Results

Selection factor (1)	Mean (2)	Rank (3)	Standard deviation (4)	Median (5)	Rank (6)	Minimum (7)	Maximum (8)
Shorten duration	2.48	1	1.68	2	1	1	7
Establish cost	3.26	2	1.73	3	2	1	7
Reduce cost	3.82	3	1.60	4	3	1	7
Constructability/innovation	3.94	4	1.88	4	3	1	7
Establish schedule	3.99	5	1.80	4	3	1	7
Reduce claims	4.58	6	1.91	5	6	1	7
Large project size/complexity	5.92	7	1.58	7	7	1	7

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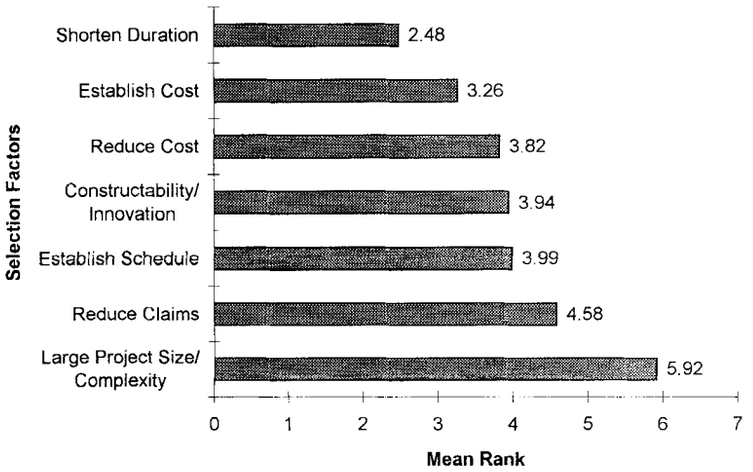

FIG. 3. Selection Factor Rankings

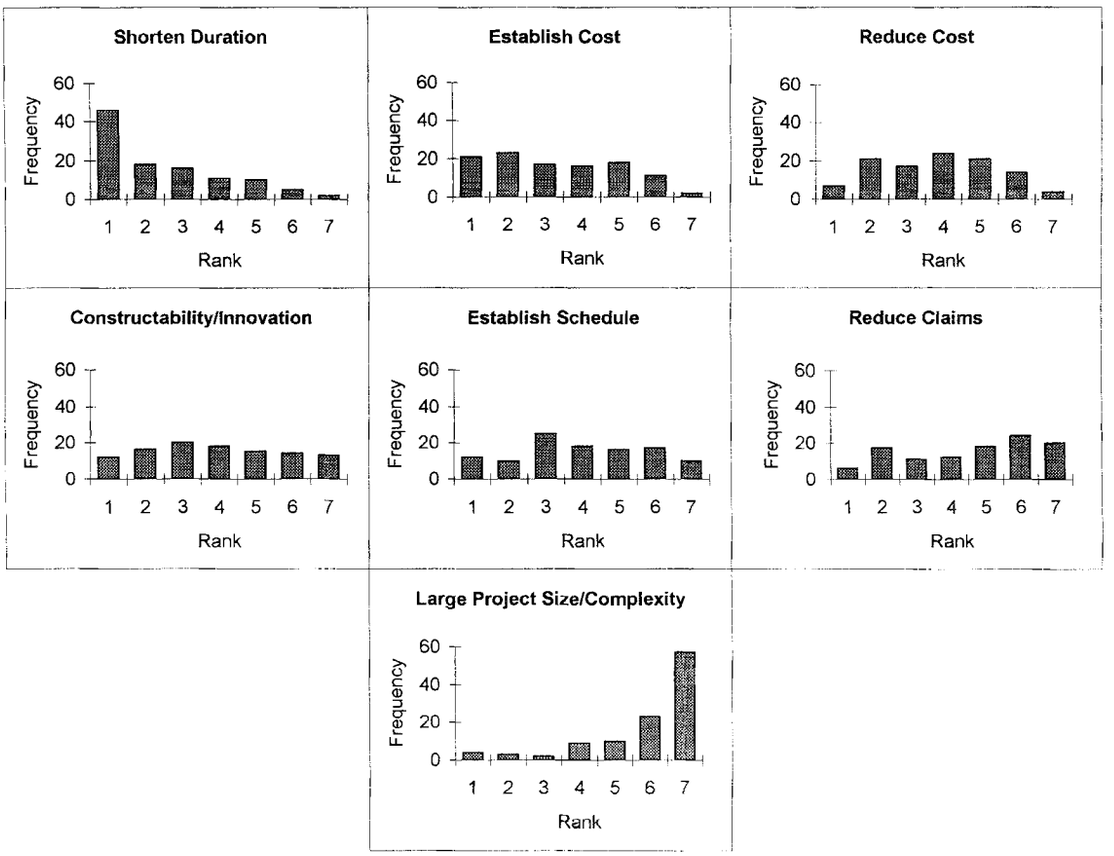

FIG. 4. Selection Factor Frequency Histograms

owners select design-build: shorten duration. Owners do not feel strongly inclined to choose design-build due to having large project size/complexity.

Although the owners only feel strongly about two of the seven factors, all factors scored at least one number 1 ranking. This illustrates, for any particular project, that any one factor can be a significant reason for choosing design-build. Therefore, in general, owners select design-build to shorten duration, but for specific projects the motivation for choosing it may be to establish cost, to reduce claims, or any of the others.

The dominance of the shorten duration and large project size/complexity display over the middle five is clearly illustrated through frequency histograms and cumulative frequency charts. The frequency histograms shown in Fig. 4 display a strong positive and negative skew for the first and last selection factors, while the middle five selection factors display an almost uniform distribution. The dominance is particularly apparent in the cumulative frequency histogram in Fig. 5. The strong concavity downward displays a positive skew while concavity upward shows a strong negative skew.

As displayed in Figs. 4 and 5, the only dominant factor is shorten duration. It has the highest mean ranking as well as the most prominent positive skew. Owners feel very strongly that design-build should be selected

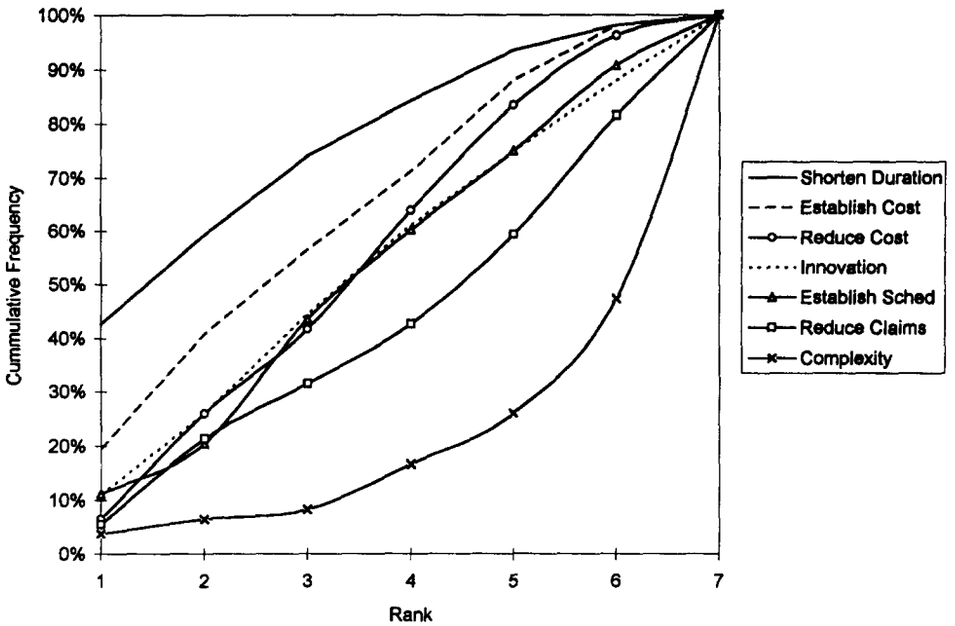

FIG. 5. Selection Factor Cumulative Frequency Chart

TABLE 3. Comparison of Public and Private Responses

Selection factor (1)	Combined		Public		Private	
	Mean (2)	Rank (3)	Mean (4)	Rank (5)	Mean (6)	Rank (7)
Shorten duration	2.48	1	2.46	1	2.53	1
Establish cost	3.26	2	3.50	2	2.85	2
Reduce cost	3.82	3	3.72	3	4.00	4
Constructability/innovation	3.94	4	3.88	4	4.05	5
Establish schedule	3.99	5	4.31	6	3.45	3
Reduce claims	4.58	6	4.01	5	5.55	6
Large project size/complexity	5.92	7	6.12	7	5.58	7

to shorten duration. The middle five selection factors have very similar mean scores and have nearly uniform frequency distributions. Therefore, shortening duration is the most prominent reason why owners select design-build.

Private and Public Sector Comparison

The second research goal was to compare private and public owner attitude toward design-build. The survey results for this goal are displayed in Table 3 and Fig. 6.

While differences between the rankings of public and private owners exist, they do not appear to be as significant as one might think. Three of the seven rankings are identical: shorten duration, establish cost, and large project size/complexity (1, 2, and 7, respectively). With the exception of establish schedule, the other selection factors are all within one ranking.

An investigation of significant differences between public and private owner attitudes toward design-build selection was performed through hypothesis testing. The hypothesis developed for this comparative study is

> There is no significant difference between the selection of design-build by public and private owners (H_0).

The resulting alternate hypothesis is

> There is a significant difference between the selection of design-build by public and private owners (H_a).

The null hypotheses (H_0) will be accepted unless statistical tests provide evidence for rejection. Rejection results in support of the alternative hypotheses.

Parametric statistics, or statistics based on test distributions, offer three statistics typically used for determining the significance between differences in two samples; the Student's t-distribution, the χ^2 (chi square) distribution, and the F-distribution (Sachs 1982). A nonparametric or distribution-free equivalent is the Wilcoxon Rank-Sum test. The writers performed tests with all four statistics and found similar results. The t-test results are presented here for clarity. The t-test compares the samples in the following manner:

$$t = \frac{\bar{X}_1 + \bar{X}_2 - \Delta}{\sqrt{S_p^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} \quad (1)$$

where $\bar{X}_1$ and $\bar{X}_2$ = means of the two samples; Δ = hypothesized difference between population means (zero in this null hypotheses); S_p^2 = pooled variance; and n_1 and n_2 = sizes of the two samples.

The specification of the rejection region was chosen to be $(\alpha) < 0.05$. In other words, there is a 95% certainty that the result is not due to chance or the finding is significant at the 0.05 level. However, since multiple t-tests were performed, this alpha value was adjusted. The multiple t-tests create joint or simultaneous confidence intervals. The Bonferroni Inequality implies that for k t-tests one should not use the α point (i.e., $\alpha = 0.05$) of the t-test but the α/k point. The adjustment yields $\alpha = 0.007$.

Therefore, results with probabilities less than 0.007 result in the rejection of the null hypothesis and probabilities greater than 0.007 will support the alternate hypoth-

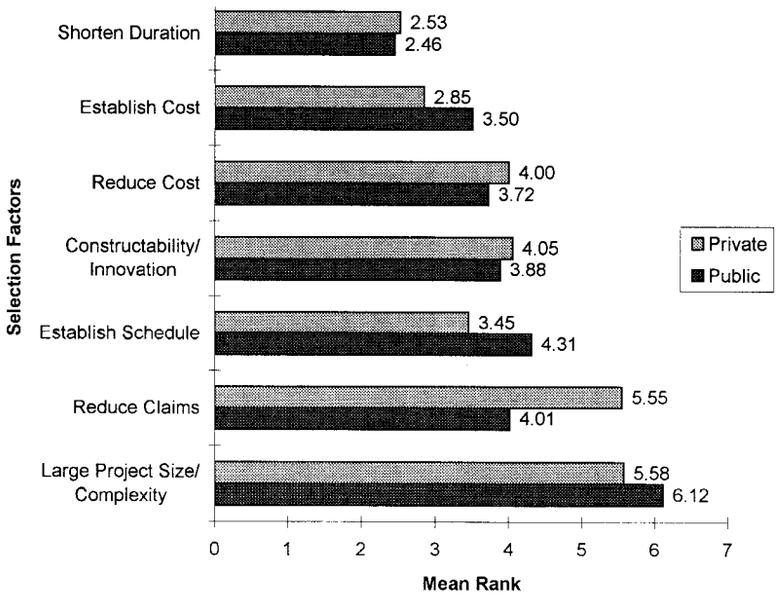

FIG. 6. Comparison of Public and Private Responses

TABLE 4. Selection Factor Mean Comparison with t Statistic

Selection factor (1)	Mean Value Comparison		t Value (4)	Probability (5)
	Public (2)	Private (3)		
Shorten duration	2.46	2.53	0.28	0.778
Establish cost	3.50	2.85	−1.75	0.084
Reduce cost	3.72	4.00	0.94	0.348
Constructability/innovation	3.88	4.05	0.10	0.919
Establish schedule	4.31	3.45	−2.55	0.012
Reduce claims	4.01	5.55	4.73	0.000
Large project size/complexity	6.12	5.58	−1.85	0.067

esis. Probabilities are calculated using the Student's t-distribution test with $n_1 + n_2 - 2$ (106) degrees of freedom. A two-tailed test must be used because the null hypotheses states that the population means are equal and not greater than or less than each other. Results of the t-tests for the individual selection factors along with their corresponding probabilities are displayed in Table 4.

Hypothesis testing demonstrates that for six of the seven selections factors, public and private owners' mean rankings are not significantly different. For the selection factor reduce claims, public and private owners feel differently. This is displayed by the high t values and low significance levels resulting in a rejection of the null hypotheses for these two selection factors. While the t-test provides support for the public and private sample differences being statistically significant, the question should be raised if there is practical support for this difference. The results show that public owners choose design-build more often to reduce claims. This difference is reasonable.

This difference is most likely due to the fact that lawsuits are much more cumbersome to deal with in the public sector. There is more red tape involved with a public claim than with a private claim. The rules of bureaucracy for the public owners do not permit negotiation as freely as they do for the private owners. Additionally, public owners come under much more scrutiny in legal claims because they are spending other people's money, namely, that of the taxpayers.

Thus, other than the reduction of claims, private and public sector owner attitudes are consistent when selecting design-build.

CONCLUSIONS

The 1990s offer both private and public owners a variety of procurement methods. Design-build is increasingly becoming a viable alternative method. The primary reason why owners select design-build is to take advantage of the time savings inherent in the process. For any specific project, additional factors that may dictate the use of design-build include establishing cost, reducing cost, constructability/innovation, establishing schedule, and reducing claims. Contrary to the inherent difference in private and public procurement procedures, design-build selection attitudes can generally be treated as the equivalent.

These documented results provide core knowledge of the design-build process for both design-build contractors and owners entering the design-build market. Considering the rationale for selecting design-build during marketing and implementation promises to enhance the success of this new, ancient method of project procurement.

ACKNOWLEDGMENTS

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APPENDIX II. NOTATION

The following symbols are used in this paper:

H_a = alternate hypothesis;
H_0 = null hypothesis;
n = size of sample;
S_p^2 = pooled variance;
t = Student's t-distribution;
$\bar{X}_1$ = mean of sample 1;
α = rejection region; and
Δ = hypothesized difference between population means.