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Chen, Qing; Jin, Zhigang; Xia, Bo; Wu, Peng; Skitmore, Martin

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Time and Cost Performance of Design–Build Projects

Qing Chen [1], Zhigang Jin [2], Bo Xia [3], Peng Wu [4], and Martin Skitmore [5]

Abstract

The design-build (DB) delivery method has been widely used in the United States due to its reputed superior cost and time performance. However, rigorous studies have produced inconclusive support and only in terms of overall results, with few attempts being made to relate project characteristics with performance levels. This paper provides a larger and more finely grained analysis of a set of 418 DB projects from the online project database of the Design-Build Institute of America (DBIA), in terms of the time-overrun rate (TOR), early start rate (ESR), early completion rate (ECR) and cost overrun rate (COR) associated with project type (e.g., commercial/institutional buildings and civil infrastructure projects), owners (e.g., Department of Defense and private corporations), procurement methods (e.g., 'best value with discussion' and qualifications-based selection), contract methods (e.g., lump sum and GMP) and LEED levels (e.g., gold and silver). The results show 'best value with discussion' to be the dominant procurement method and lump sum the most frequently used contract method. The DB method provides relatively good time performance, with more than 75% of DB projects completed on time or before schedule. However, with more than 50% of DB projects cost overrunning, the DB advantage of cost saving remains uncertain. ANOVA tests indicate that DB projects within different procurement methods have significantly different time performance and that different owner types and contract methods significantly affect cost performance. In addition to contributing to empirical knowledge concerning the cost and time performance of DB projects with new solid evidence from a large sample size, the findings and practical implications of this study are beneficial to owners in understanding the likely schedule and budget implications involved for their particular project characteristics.

Key words: Delivery, Design-build, construction industry, time performance, cost performance, project characteristics.

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[1] Vice General Engineer, Green Building Research Centre, Gasu Adorn Design Engineering Co. Ltd, 3076 Qiaoxiang Road, Futian District Shenzhen, China, Email: richard.q.ch@gmail.com
[2] Associate Professor, College of Architecture and Environment, Sichuan University, Chengdu 610065, China Email: jzg83cn@hotmail.com. (corresponding author)
[3] Senior Lecturer, School of Civil Engineering and Built Environment, Queensland University of Technology, 2 George Street, Brisbane QLD 4000, Australia. Email: paul.xia@qut.edu.au
[4] Senior Lecturer, Department of Construction Management, Curtin University, Perth, Australia. Email: peng.wu@curtin.edu.au
[5] Professor, School of Civil Engineering and Built Environment, Queensland University of Technology, 2 George Street, Brisbane QLD 4000, Australia. Email: rm.skitmore@qut.edu.au

Introduction

Design-build (DB) is an integrated approach that delivers design and construction services under one contract with a single point of responsibility (Songer and Molenaar 1997; Design-Build Institute of America 2014). It is increasingly popular not only in the U.S. but also in the international construction market due to its advantages such as shorter project duration, early project cost certainty and single point responsibility for clients (e.g. Konchar and Sanvido 1998; Xia and Chan 2008; Hale et al. 2009).

Due to the completion of an increasing number of DB projects in the U.S., a number of empirical studies have been conducted into DB performance and in comparison with other delivery methods (e.g. Konchar and Sanvido 1998; Molenaar et al. 1999; Ibbs et al. 2003; Warne 2005; Hale et al. 2009). In general, DB is found to be superior to the traditional delivery system in terms of time and cost performance (Xia et al. 2012a). However, the sample sizes in these studies are generally quite small - the majority being less than 50 with the largest sample of 155. Additionally, some project performance evidence is opinion-based from questionnaire surveys of project participants rather than factual project information. Furthermore, rigorous studies have produced inconclusive support and only in terms of overall results, with few attempts being made to relate project characteristics with performance levels. An empirical study with a larger sample size to examine factual, finer performance data of DB projects is therefore necessary to obtain solid research findings.

The Design-Build Institute of America (DBIA) is the only organization that defines, teaches and promotes best practice in DB (DBIA 2014). It provides a variety of resources, including an online DBIA Project Database that is available to the public. The database contains hundreds of completed DB projects. At the time of this research, these comprised 428 DB projects completed within the last 10 years. For each project, a brief project introduction, project team, project overview (e.g. project cost, schedule, procurement methods, etc.) are available along with additional information such as LEED certification, awards, lessons learnt and innovation/creativity. This paper provides an analysis of this data to establish more clearly the effect of DB and associated project characteristics concerning project time and cost performance. In so doing, in addition to contributing to empirical knowledge concerning the cost and time performance of DB projects, the findings and practical implications of this study are of benefit to owners in understanding the likely schedule and budget implications involved for their particular project characteristics.

Literature review of time and cost performance of DB projects

The vast majority of construction projects experience time and cost overruns (e.g. Chan and Kumaraswamy 1997; Odeh and Battaineh 2000; Assaf and Al-Hejji 2006). This is especially the case with the increasing size and complexity of modern contraction projects, where time and cost overruns cause a significant capital loss for project owners. As a procurement method, DB offers a number of strengths to overcome such time and cost problems. It is considered the fastest project delivery system, for example - the main reason for its use (Songer and Molenaar 1996). This is because the DB system encourages an overlapping of the design and construction process. Additionally, the number of change orders, a major source of project delays, is less likely due to the improved communication between the design team and design-builder (Assaf and Al-Hejji 2006). Project cost is also more certain with DB than with some other methods, as the DB contract is usually awarded on a lump-sum basis during the early stages of projects, which provides the owner with an early estimate of project cost. Moreover, as the DB method allows design-builders to have total control over design, scope and budget, it is more likely that DB projects will be completed within budget and schedule.

With the availability of DB project data over the years, a number of empirical studies have been made to investigate DB project performance, mainly in terms of cost and schedule. Konchar and Sanvido (1998), for example, have compared the cost, schedule, and quality performance of three project delivery systems (DB, construction management at risk and traditional design-bid-build), finding the median cost and schedule growth of 155 DB projects to be 2.17% and 0% respectively - 5.2% and 11.4% less than design-bid-build (DBB) projects. Similarly, Molenaar's (1999) study of 104 DB projects found 59% within 2% of the budget, and 77% within 2% of the schedule, established when the design-builder was hired. Ibbs et al.'s (2003) study of a further 24 DB projects found they experienced an average 7.4% cost increase (higher than DBB) and 4.1% schedule increase (lower than DBB). Hale et al.'s (2009) study of 39 U.S. DB military buildings found an average 2% cost and 11.5% schedule growth, both being significantly less than DBB projects.

The use of DB for infrastructure procurement shows a similar pattern, with 16 of Warne's (2005) 21 U.S. DB highway projects having finished ahead of schedule. According to a U.S. Federal Highway Agency (2006) survey of 69 DB projects, DB project delivery reduces overall cost and duration by an average of 3% and 14% respectively. Compared with 11 DBB projects, the cost growth for DB is 3.8% higher, and schedule growth for DB is 9% lower.

In DB project delivery, selection of the appropriate procurement method is important to project success. The four primary procurement procedures are low-bid, best value, qualifications-based and sole-source procurement (Molenaar et al. 2010). As DB combines both design and construction under one umbrella, project owners normally expect that DB contractors will provide the best value and not just the lowest price (Palaneeswaran and Kumaraswamy 2000; Molenaar et al. 2004). Molenaar et al. (1999) compare the time and cost performance of DB projects using one-step low-bid, two-step best value, and qualification based procurement methods, finding that the best value (two-step) procurement method possesses the least cost and schedule growth, followed by the low-bid (one-step) and qualification-based procurement methods. The major reason for the improved performance of two-stage best value procurement is that the scope of the best value procurement method is typically well defined, with around 35% of design provided in the request for proposals (Molenaar et al. 1999). Additionally, the best value procurement method normally uses the process of short-listing to only qualified bidders with a proven track record of time and cost performance, which will largely ensure and improve project performance. The one-step low-bid method does not short-list bidders who are normally selected based on the lowest price. This may lead to the award to a low bidder who has a poor cost and schedule performance record. Furthermore, according to Gransberg and Senadheera (1999), the best-value method is the most flexible approach since it allows the owner to simultaneously evaluate factors that are specific to each project. It enables owners to select the best-qualified design-builders for a specific project and leads to the best project performance. For the qualification-based method, although it should theoretically enhance performance as it uses prequalification, its advantages are outweighed by the lack of competition during the proposal stage (Molenaar et al.1999; Xia et al. 2012b).

El Wardani et al. (2006) quantitatively analyze the correlation between design-build procurement methods and the performance of design-build projects with regard to cost, time and quality metrics. This reveals that the qualifications-based and best value selection method results in the lowest cost and schedule growth respectively. That best value selection results in the lowest schedule performance is consistent with Molenaar et al.'s (1999) finding. Meanwhile, the low-bid method has the highest cost growth. This is due to low-bid procured projects typically involving frequent change orders during the course of construction (Beard et al. 2001). The study also found that the best value selection was outperformed by the other selection approaches in terms of quality. However, the limited sample size did not allow the statistical verification of these conclusions.

In general, therefore, DB projects have better cost and time performance than DBB projects. However, time delays and cost overruns are still common in DB projects (Ibbs et al. 2003; EI Wardani et al. 2006; Xia and Chan 2008; Ling and Poh 2008). It is important to note, also, that the difference in results obtained by these previous studies is largely unaccounted for, and the sample sizes involved are quiet small.

Research Methodology

The method used is both exploratory and explanatory. Although DB is superior in theory to the traditional delivery system in terms of time and cost performance, evidence from empirical studies are unconvincing due to their small sample sizes and occasionally contradictory results. Exploratory research helps in gaining further insight into this issue and aims to obtain more reliable results based on a large sample of real DB projects. Explanatory analysis is also conducted to reveal the underlying relationships between project characteristics and performance levels and relate current findings to those obtained previously.

Secondary data analysis is conducted, using data previously collected and tabulated by other resources from the online DBIA Project Database (http://www.weembo.com/DBIA/Projects). The data for each project comprises the project title, location, brief project description, project team, project overview (including contracted construction start date, actual construction start date, contracted construction completion date, actual completion date, contracted total project cost, actual total project cost, project size, procurement/selection criteria, contract terms and evaluation criteria). Additional information includes LEEDs certifications, awards, lesson learned and innovation/creativity. These data are suitable for explorative and explanatory research purposes and were collected during June to July 2014 and coded based on project characteristics. The quantitative data analysis is conducted mainly to examine time performance (in terms of time-overrun rates, early start rates and early completion rates) and cost performance (in terms of cost overrun rates) and investigates how different project characteristics affect time and cost performance.

Data description

The DBIA was established in 1993 to promote DB as a delivery method. At the time of data collection (end of July 2014), there were 428 DB projects in the DBIA database. Of these, 10 projects are located outside the United States (e.g. Canada, Pakistan, Iraq, etc.) and are not included in this analysis due to the different social and market conditions overseas. The remaining projects cover 47 states (except Maine, Arkansas, and West Virginia), with a total cost of USD$32 billion (average USD$79 million per project).

Table 1 summarizes the characteristics of the 418 projects in terms of type, owner, procurement method, contract method, LEED level and ranked by frequency of occurrence. This shows commercial and institutional buildings to be the dominant project type, followed by civil infrastructure projects and industrial process facilities. Public owners account for 62.3% of the total owner agencies. This is due to the 1996 Federal Acquisition Reform Act authorizing the use of DB for federal projects, since when there has been an increasing use of DB in the public sector (Molenaar et al. 1999). In particular, the Department of Defense (DOD) was the first federal agency to use DB and is the largest in terms of the number of completed DB projects.

The procurement method denotes the process of buying and obtaining the necessary property, design, contracts, labor, materials and equipment to build a project (Molenaar et al. 2010), with the four primary methods being low-bid, best-value (including fixed budget/best design), qualifications-based, and sole-source procurement (Beard et al. 2001). With low-bid selection, the owner selects the design-builder that can deliver the project with the lowest cost. For best value selection (including fixed budget/best design), prospective DB contractors are evaluated based on both technical and financial aspects of the project. Before the final contract award, negotiations normally take place with contractors offering the best value. With qualification-based and sole source selection, the DB team is selected based on qualitative criteria such as past performance, organization capacity and project understanding (Xia et al. 2012b). As is shown in Table 1, best value is the dominant DB procurement method, accounting for more than 60% of the projects. This is recognized as being due to best value being the most flexible approach as it allows the owner to evaluate factors that are specific to each project (Gransberg and Senadheera 1999).

Of the contract methods used, lump sum is the most common for DB contracts generally (Bogus et al. 2010) and proves to be the case with this database too. With lump-sum contracts, the design-builder agrees to complete the project for a fixed price and assumes the risk of cost overruns. The second most popular contract, guaranteed maximum price (GMP), establishes a price that cannot be exceeded and is usually negotiated based on conceptual planning documents rather than the more detailed plans and specifications used in traditional competitive bidding (Xia et al. 2012c). It provides owners with the benefit of an overall cap on project cost. For cost-plus-fee contracts, design-builders are paid based on their actual costs (subcontractor costs, labor, materials, etc.) plus a fee that can be a fixed amount, or a percentage of final cost, to cover overheads and profit.

U.S. owners predominantly communicate their desired level of sustainability through the leadership in energy and environmental design (LEED) certification system (Xia et al. 2013). Nowadays, DB is an effective means of delivering high-performance sustainable construction projects (Molenaar et al. 2010) and an increasing number of U.S. governments (e.g. US General Services Administration, California government, etc.) have encouraged or mediated LEEDs certification for public projects. This occurs with 38.8% of the projects, with LEEDs Silver and LEEDs Gold being the most frequent sustainability requirements.

Time performance analysis

Figure 1 shows the distribution of the time overrun rates (TOR) for all the projects, where TOR measures the change between the planned and actual project duration, defined as TOR = (actual total project duration–contracted total project duration)/contracted total project duration. The TOR values have a mean of 0.15% (overrun), and range from 52% time saving to 169% time delay, with the majority of projects completed on schedule. In terms of frequency, 33.0% of projects were completed on time and 43.9% ahead of time, with the remaining 23.1% being completed behind time.

One of the primary advantages of DB projects is considered their shorter project duration, because construction can be started before the full completion of design work, allowing for fast track and parallel design and construction processes. This is reflected in the early start rate (ESR), which measures whether DB construction started at the time stipulated in the contract, where ESR=(contracted construction start date–actual construction start date)/(contracted construction completion date–contracted construction start date). By this measure, 80.4% of the projects started on time, with only 14.8% starting late.

For many projects, especially commercial buildings, early completion means early occupancy and reduced financing expenditure, which is a major reason many use the DB method. The early completion rate (ECR) measures whether the project was completed on time, where ECR= (contracted completion date–actual completion date)/(contracted completion date–contracted start date). This indicates that 37.5% of projects were completed on time and 21.8% were completed later, with the remaining 40.7% being completed early.

Table 2 summarizes the ANOVA tests on the time performance of DB projects within different project characteristics (project type, owner, procurement method, contract method and LEED levels). This shows TOR and ESR to be significantly different ($p<0.05$) between projects with different procurement methods, with low-bid procurement projects having a clearly longer time overrun (time delay) and earlier starting time. This is most likely due to the design of low-bid DB projects being well advanced at the time of procurement (Molenaar and Gransberg 2001) and hence enabling the early start of construction work upon selection of the successful contractor as most of the project scope is already clearly defined and approved.

Cost performance analysis

The cost overrun rate (COR) measures the change between the planned and actual project cost, where COR= (actual total project cost–contracted total project cost)/contracted total project cost. Figure 2 shows the distribution of the COR values. These have a mean of 6.9% (cost overrun), with range -38% to 286%. In this case, 54.9% overran on cost, while 18.2% saved on cost.

The ANOVA results for cost performance within different project characteristics indicate that projects with different types of owners and contract methods have significantly different COR values (Table 3), with Federal (non Department of Defense) projects clearly experiencing the greatest cost overrun (average 34%).

In terms of different contract methods, projects with GMP have the best cost performance. This is to be expected, as costs incurred above the GMP are the responsibility of the design-builder and are not reimbursed by the owner. The average cost overrun in DB projects using cost-plus-fee contract is

20.06%, which is significantly higher than are those for lump sum and GMP. As payment is based on the actual costs incurred during the project, the contractors normally have less incentive to reduce cost. As a result, public sector procurement codes often exclude the use of cost-plus-fee provisions for construction contracts to protect the owner from excessive cost growth (Bogus et al. 2010).

Finally, although the ANOVA tests show there is no statistically significant difference between procurement methods ($p=0.076>0.05$), it can be seen that projects with qualification-based and sole source selection methods have much lower cost overrun than those using low-bid and fixed budget/best values. This result is largely consistent with the findings in EI Wardani (2006).

Discussion

The data analysis indicates that DB projects generally have a comparatively better time performance than cost performance. As summarized from the literature review, the time performance of DB projects ranges from 14% schedule reduction (U.S. Federal Highway Agency 2006) to 11.5% schedule growth (Hale et al. 2009), with the majority of schedule growth less than 8% (e.g. Konchar and Sanvido 1998; Molenaar 1999; Bogus et al. 2010; Ibbs et al. 2003). With an average time overrun of 0.15%, and more than 75% of DB projects having shorter or as-scheduled project duration, the time performance of the DBIA DB projects is similar to, or better than, most previous studies, thus significantly better than the time performance of the DBB method (normally more than 5%). The shortened duration/early completion of DB projects has been widely recognized in previous research and is known to be one of the most important incentives for project owners to use DB (Songer and Molenaar 1996; Lin and Lau 2002). According to Songer and Molenaar (1996), the primary reason why both public and private owners select DB is to take advantage of the time saving inherent in the process. Ibbs et al. (2003) also found changes in schedule, in both absolute and relative terms, to be less in DB than DBB.

Establishing and saving cost are also primary reasons for owners selecting DB (Songer and Molenaar 1996). This is supported by Molenaar et al.'s (1999) research, in which only 54.9% of the DB projects studied overran on cost, with 59% being within 2% of the established budget. With an average cost overrun of 6.9%, this is comparatively better than DBB, which is generally in the order of 5-15% (e.g. Konchar and Sanvido 1998; Ibbs et al. 2003; Shrestha 2007). The majority of previous research also supports the conclusion that DB has a comparatively better cost performance than DBB but generally in overall and qualitative terms (e.g. Roth 1996; Konchar and Sanvido 1998; Warne 2005). What is needed is a more comprehensive comparison of cost performance between various project delivery systems. More importantly, the underlying reasons leading to different cost performance are also in need of investigation.

The ANOVA test of time-overrun performance between different procurement methods shows that qualification-oriented selection results in better time performance than cost-oriented selection. The major reason for this is that with qualification-oriented selection, many projects are still in the early design stage (normally the schematic design), which enables DB contractors to better control their projects and contribute more innovative input to project design (Xia et al. 2013). This leads to better constructability and speedier construction. Additionally, as low-bid procurement selection is normally applied when the majority of design is completed, the project schedule cannot be further shortened because of the lack of integration of a fixed sequential schedule from the design to construction phases (Chritamara et al. 2002). Another possible reason is that the traditional selection of the lowest bidder typically results in a high number of change orders during the course of construction, which can significantly delay the project (Beard et al. 2001).

The ANOVA tests also reveal that cost performance varies between types of owner and contract methods. In comparison with other projects, Federal (non Department of Defense) DB projects experience very lengthy time delays (34%). A close examination of the Federal (non-DoD) projects indicates that these over-budget DB projects are normally large and complex (research facilities, engineering facilities, etc.). Large and complex construction projects have historically significant cost overruns (Flyvbjerg et al. 2002) as managing large and complex construction projects requires the coordination of a multitude of human, organizational, technical and natural resources, and the design and construction of such complex projects is overshadowed by economic, societal and political challenges (Shane et al. 2009).

For contract methods, cost-plus-fee contracts tend to lead to greater cost overruns (average 20.06%). This is understandable given that, in this contract arrangement, contactors normally lack incentives to reduce costs (Berends 2000). Only 19 DBIA projects used this contact type, as extensive owner involvement is required and most owners lack the resources needed. As a result, its use is normally restricted to the procurement of design services. In order to reduce the owner's cost risk, the payment provision of cost-plus fee typically includes a GMP for a DB contract (Bogus et al. 2010). With a lump sum contract, the contractor is paid a fixed price to carry out all the work required by the agreement. To reduce the risk for contractors, a lump sum contract is normally used when the scope of the work is more clearly defined (Kaplanogu and Arditi 2009). Otherwise, a GMP contract is usually used in the early project stages, where the contractor undertakes the agreed scope of work at a price not exceeding the GMP. These results correspond with Bogus et al.'s (2010) finding that GMP contracts result in better cost performance for owners.

Conclusions

The DB delivery system has gained popularity in the U.S. construction industry for several reasons, particularly its claimed superiority in terms of cost and time performance. Empirical research to date, however, has had mixed results, partly due to small sample sizes and lack of analysis of determining project characteristics. This paper examines the time and cost performance of a larger sample of 418 DB projects listed in the DBIA database. The results show that 'best value with discussion' is the dominant procurement method for contractor selection and the 'lump sum' is the most frequently used contract method. The data analysis indicates DB projects to have a relatively good time performance, with more than 75% being completed either on, or ahead of, schedule. Despite DB cost performance being found to be better than DBB's in a number of previous studies, this is not confirmed here as more than 50% of DBIA DB projects are over-budget.

Further analysis also revealed that the procurement method significantly affects time performance. A qualification-oriented rather than cost-oriented contractor selection process results in less time overruns. Whether this is due to more optimistic time budgeting with cost-oriented selection is not known at this stage. Additionally, different owner types and contract methods significantly affect cost performance. The GMP contract method also appears to be more suitable if cost performance is the primary goal of owners as it results in the least cost overruns (although it is possible that owners using GMP set targets that are more realistic).

The contributions of this research are twofold. First, it provides solid evidence (using a much larger sample with real project performance data, not opinioned based, compared with previously studies) to confirm the pattern (the well-recognized DB project performance) in the existing body of knowledge with more reliable and sound research findings. Second, the project characteristics that significantly affect performance levels have been identified. Although it does not reveal causal relationship between these project characteristics and project performance, it provides empirical evidence for further exploration.

The findings, while not unexpected, provide a number of implications for various project stakeholders. Although focused on just DB project delivery, the empirical findings are compelling when added to the body of research and understanding underlying such methods. Given the large sample size used, the average time and cost performance of the sample projects can be used by project owners for benchmarking the project performance of future DB projects. Similar project performance data from alternative project delivery methods (e.g. DBB, CM) is needed for quantitative comparison. However, it should be noted that project quality is not taken into account due to the lack of relevant information, and therefore the possibility that the benefits of DB may at the expense of quality cannot be ruled out at this stage. This is especially the case for federal government agencies (non-DOD), where DB projects have severe time and cost overrun problems and the underlying reasons need to be further investigated. The findings of such research may result in a change in the federal government's current procurement policies. For the majority of DB clients, however, best value procurement with the lump sum/GMP contract method is recommended as the most effective contractor selection approach given its significantly better cost and time performance levels.

As DB projects perform significantly different with different procurement methods, owner and contract types follow up studies that further investigate the effect of these variables on time and cost performance will be beneficial to both owners and contractors. In addition, a further investigation of the underlying reasons for the time and cost overruns of the sample projects will both help validate the findings of this study and help improve current DB delivery practices.

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Table 1. Project characteristics

Characteristic	Frequency	Percent
Project type:		
Commercial/institutional buildings	254	60.8%
Civil infrastructure projects	117	28.0%
Industrial process facilities	44	10.5%
Other	3	0.7%
Owner:		
Government-federal agency (DOD)	94	22.5%
Private corporation	77	18.4%
Government-state agency	61	14.6%
Municipal	50	12.0%
Government-local agency	46	11.0%
Other	34	8.1%
Non-profit corporation	25	6.0%
Developer	22	5.3%
Government-federal agency (Non DOD)	9	2.2%
Procurement method:		
Best value with discussion	204	48.8%
Qualifications-based selection	102	24.4%
Best value with no discussions	52	12.4%
Sole source	20	4.8%
No information provided	16	3.8%
Other	11	2.6%
Fixed budget/best design	9	2.2%
Low-bid	4	1.0%
Contract method:		
Lump sum	211	50.5%
Guaranteed Maximum Price (GMP)	127	30.4%
Other	39	9.3%
No information provided	22	5.3%
Cost plus fee	19	4.5%
LEED level:		
No level	256	61.2%
Gold	67	16.0%
Silver	61	14.6%
Certified	17	4.1%
Platinum	17	4.1%

Table 2. Time performance ANOVA tests for differences within project characteristics

Category	Mean time overrun	*p*	Mean early start	*p*	Mean early complete	*p*
Project type:						
Commercial/institutional buildings	-1.03%		-1.81%		-0.75%	
Civil infrastructure projects	0.53%	.103	-1.04%	.118	-1.60%	.461
Industrial process facilities	5.89%		1.21%		-4.75%	
Owner:						
Developer	-2.53%		-0.89%		1.78%	
Government-federal agency (DOD)	-1.09%		-1.67%		-0.65%	
Government-federal agency(Non DOD)	21.75%		-0.25%		-22.00%	
Government-local agency	1.20%		-0.56%		-1.78%	
Government-state agency	2.00%	.057	-0.88%	.998	-2.86%	.104
Municipal	-1.87%		-1.76%		0.13%	
Non-profit corporation	-4.00%		-1.71%		2.53%	
Other	-4.66%		-1.69%		2.97%	
Private corporation	2.47%		-0.93%		-3.32%	
Procurement method:						
Low-bid	27.50%		27.75%		0.00%	
Fixed budget/best design	13.00%		-3.44%		-16.44%	
Best Value with no discussions	-0.04%		-1.12%		-1.18%	
Best value with discussion	0.99%	.018*	-1.76%	.000**	-2.76%	.136
Qualifications-based selection	-3.04%		-1.37%		1.77%	
Sole source	-1.33%		-1.67%		-0.27%	
Other	-6.27%		-1.36%		4.91%	
Contract method:						
Lump sum	0.23%		-1.25%		-1.48%	
Guaranteed Maximum Price (GMP)	-2.15%	.171	-1.91%	.411	0.32%	.460
Cost plus fee	8.11%		1.94%		-6.22%	
Other	2.74%		-1.08%		-3.95%	
LEED level:				.546		
No LEED level	1.04%		-1.25%		-2.28%	
LEED Certified	-3.25%		0.75%		3.81%	
LEED Silver	-0.08%	.768	-1.16%		1.12%	.590
LEED Gold	0.69%		-2.41%		-2.23%	
LEED Platinum			1.13%		0.44%	

Table 3. Cost performance ANOVA tests for differences within project characteristics

Category	Mean cost overrun	p-value
Project type:		
Commercial/institutional buildings	6.47%	.220
Civil infrastructure projects	5.81%	
Industrial process facilities	12.57%	
Other		
Owner:		
Developer	9.53%	.008*
Government-federal agency (DOD)	8.03%	
Government-federal agency(Non DOD)	34.00%	
Government-local agency	3.49%	
Government-state agency	10.88%	
Municipal	3.09%	
Non-profit corporation	7.53%	
Other	1.09%	
Private corporation	5.01%	
Procurement method:		
Low-bid	10.25%	.076
Fixed budget/best design	20.33%	
Best Value with no discussions	6.39%	
Best value with discussion	9.47%	
Qualifications-based selection	2.20%	
Sole source	0.41%	
Other	3.64%	
Contract method:		
Lump sum	8.70%	.015*
Guaranteed Maximum Price (GMP)	3.07%	
Cost plus fee	20.06%	
Other	5.53%	
LEED level:		
No LEED level	6.84%	.437
LEED Certified	2.06%	
LEED Silver	4.56%	
LEED Gold	11.06%	
LEED Platinum	4.44%	