 

# Performance of Design-Build Projects: Current State and Comparison between Project Characteristics

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This study attempts to quantitatively analyze performance of Design-Build (DB) projects completed in the last ten years from multiple perspectives. In order to improve the DB delivery method it is essential to observe the current state of performance and identify problems. Schedule growth and cost growth have been utilized to compare the project performances because of their measurability and objectivity. Further, the performance levels were compared between groups established according to building categories. It was observed that DB projects could achieve shortened schedule but the actual cost exceeded the proposal budget cost. Medical projects have shown the least of schedule variation with minimal delays. No significant association was discovered between the level of performance and the size of projects. It is concluded that the DB method is a more appropriate approach for owners and practitioners who are willing to achieve time saving, although risks in uncertainties of projects will be present. The main objective of this study is to provide owners and practitioners with better understanding of the DB delivery before they adopt it for their projects.

**Keywords:** Project delivery method, design/build, schedule growth, cost growth

## Introduction

The need for efficient construction practices has been advocated for several decades. While other sectors, such as manufacturing, agriculture, transportation, etc. made noticeable improvements in productivity, the construction industry demonstrated a downward trend with considerable amount of non-value-added activities (Teicholz, 2009). The inherent complexity and unpredictable nature of the construction tasks contribute to the lack of efficiency noticed in the industry. Further, the unique setup of construction projects that is characterized by unfamiliar groups of people coming together to work for short periods of time adds to the complexity and inefficiency. The construction projects, which are temporal in nature are often disrupted with adversarial relationships among the key stakeholders that include the owners, designers, and contractors (Furst, 2010). With each of the stakeholders focused on realizing individual goals and transferring maximum possible liabilities to others through contractual relationships, conflicts and disputes far outweigh the collaborative efforts among the stakeholders. The lack of collaboration has detrimental effect on the coordination among the stakeholders that in turn affects the project performance negatively. The outcome of this situation is reflected in the results of a survey conducted by ENR (Post, 1998) that showed 33% of the construction projects finished over budget, 42% of the projects ran behind schedule, and 13% of the projects had pending claims and litigations.

Practitioners and scholars have sought for innovative ways to solve the problem of lack of collaboration among stakeholders in the construction industry. Design-Build (DB) project delivery method, an alternative to traditional Design-Bid-Build (DBB) method emerged as one of the solutions to improve the collaboration among stakeholders in construction projects, and thus improve the efficiency of the industry. The Design-Build Institute of America (DBIA) (2013) defines design-build as an integrated approach that delivers design and construction services under one contract with a single point of responsibility. DBB by comparison, is a delivery method where the designer and contractor have individual contracts with the owner, and phases of the work are typically handled separately and completed in a linear sequence. In the last decade, the use of DB delivery method has increased considerably in the US construction industry, especially in the non-residential sector. According to DBIA (2013), DB has reached 40% of non-residential construction market share over the past 15 years.

Numerous studies compared project performances of DB delivery method with that of DBB. Review of existing literature revealed that construction speed and project delivery speed of projects utilizing DB were significantly faster than that of DBB projects (Shrestha et al. 2012; Konchar, 1997). In a 2013 study that compared the water and wastewater plants delivered using DB with those delivered using DBB found the schedule growth for DB projects was significantly less than that of DBB projects (Shane et al., 2013). Results from the study also revealed that DB projects were more often completed below budget in comparison to DBB projects. In their work, Hale et al (2009) demonstrated that in comparison to DBB method, DB method improved project outcomes across multiple measures including project duration, time growth, and cost growth.

In contrast to the number of studies comparing project outcomes of DB and DBB projects there have been a limited number of research studies investigating how DB projects perform in terms of their own schedule and cost. Shane et al. (2013) identified reasons that led owners to select the DB delivery method as: 1) time savings/speed of delivery; 2) construction quality/problems with low-bid work; 3) cost savings/price certainty; 4) single-point accountability; and 5) builder involvement in the design process.

A database maintained by DBIA (http://www.weembo.com/DBIA/Projects) provides a plethora of information on more than 400 DB projects completed since 2004. The information contained in the database includes the individual project characteristics, as well as the key performance indicators for each of the projects. The authors reviewed and analysed the information available in the database to develop a baseline understanding of the characteristics and performance of each project listed. The objective of this paper is to identify if there is any relationship between the project characteristics and project performance. This paper will add to the existing knowledgebase by shedding light on the current state of DB projects. While the work of Molenaar et al. (2004) investigated the water/wastewater sector in depth, this paper focuses on the overall performance of DB projects in various building categories following a similar approach. The findings of this paper will inform the owners and practitioners to evaluate the effectiveness of DB method before adoption, as well as identifying possible improvement in the future.

## Problem Statement

The goal of the paper is to examine the characteristics of DB projects that yield improved performance. The specific objectives are: (1) to analyze the performance of DB projects completed between 2004 and 2013 based on two critical performance indicators - schedule and cost; (2) to identify any association between project characteristics and level of performance; and (3) to determine project characteristics and conditions that are conducive to DB delivery method.

Performance is often measured by both objective and subjective methods. Schedule and cost are objective criteria that are easily measured and compared, whereas subjective instruments typically consist of client satisfaction, aesthetics, etc. (Chan et al. 2002). Time and cost can be utilized for performance analysis, as long as the project data sources are reliable. To emphasize the essence of time, the directors of several transit projects stated that the ability to achieve an aggressive compressed schedule is the most influential factor when selecting alternative delivery methods (Touran et al., 2011). Schedule and cost being objective criteria, this paper focuses on those two as performance criteria for factual assessment, but future research can look into filling the gap between objective and subjective criteria.

## Method

Project characteristics and performance data about the individual projects were collected from the DBIA website (http://www.weembo.com/DBIA/Projects). A total of 407 projects that were successfully completed in the US during 2004 to 2013 were included in the review. For project characteristics, information on project location, category, size, LEED certification, etc. were extracted from the database. To measure project performance, schedule growth and cost growth were computed from the available information using the two equations shown below in this section.

To calculate schedule growth, the original project duration was calculated using the proposal start date and completion date (proposal duration = proposal completion date – proposal start date). Next, the actual start date and actual completion date were used to compute actual duration (actual duration = actual completion date – actual start date). The following equation was used to calculate schedule growth:

Schedule Growth (%) = [(Actual Duration – Proposal Duration) / (Proposal Duration)] × 100

To calculate cost growth, information about the original cost and actual cost were collected and the difference between the two were computed to determine the project cost modification amount. Pocock (1996) defined the cost growth as the percent difference between the proposal budget cost and the actual as-built cost. The following equation was used to calculate cost growth:

Cost Growth (%) = [(Actual Cost – Proposal Budget Cost) / (Proposed Budget Cost)] × 100

Subsequent to extraction and organization of the data, the data was analyzed. The following section presents the findings from the data.

## Findings

Based on the information available in the DBIA website, out of the total 407 projects considered for this review, only a few were completed during 2012 and 2013 (see Figure 1). The authors don't think this is representative of the nature of the construction industry, and might be due to the time lag for the database updating process. As a general trend, the number of DB projects increased gradually from 2003 reaching the peak during the years 2009-2010. As mentioned previously, this trend is reflective of the increasing popularity of the DB method across the construction industry. As evident from the database, the West Coast and the East Coast have adopted DB more in comparison to the rest of the nation. As illustrated in Figure 2, a vast majority of the completed projects are located in the two coasts. The five states with most number of completed DB projects as of the date when the information was extracted from the DBIA database are California (69), Virginia (30), Florida (28), Colorado (24), and Texas (18).

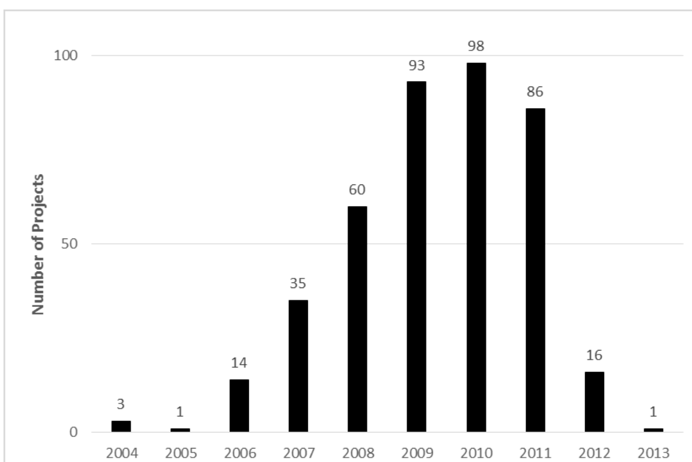


Figure 1: Number of DB projects completed each year from 2004-2013

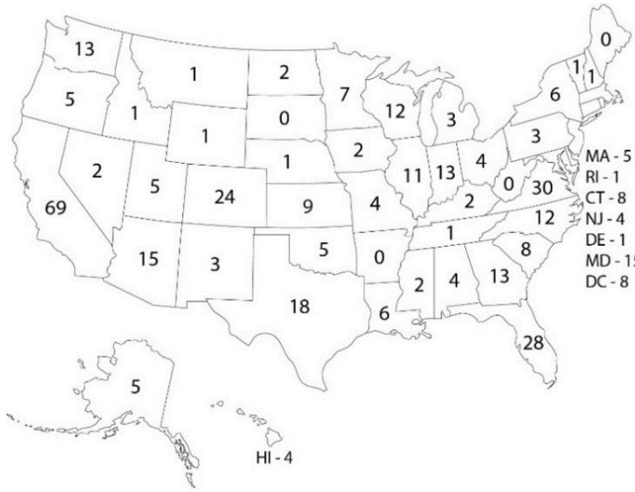


Figure 2: Geographic distribution of DB projects completed from 2004-2013

In terms of category of projects that have adopted DB as the delivery method, military projects lead the group followed by educational, and water & sewer (see Figure 3). The authors have used the classification of building categories as per Reed Construction Data for this purpose. It is interesting to notice that water & sewer projects have utilized DB substantially as DBB is still the preferred form of delivery method in majority of the public projects. Projects adopting DB varied in sizes from less than 10,000 SF to projects in excess of 1,000,000 SF (see Figure 4). While doing the classification, the authors have excluded the projects where square foot has not been used for measurement of facility sizes. One hundred and ten projects were excluded that primarily belonged to the transportation, and water & sewer sectors.

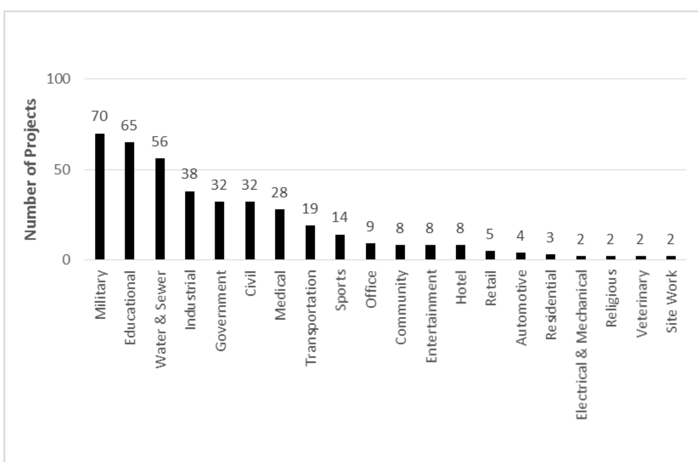


Figure 3 – Categories of DB projects completed from 2004-2013

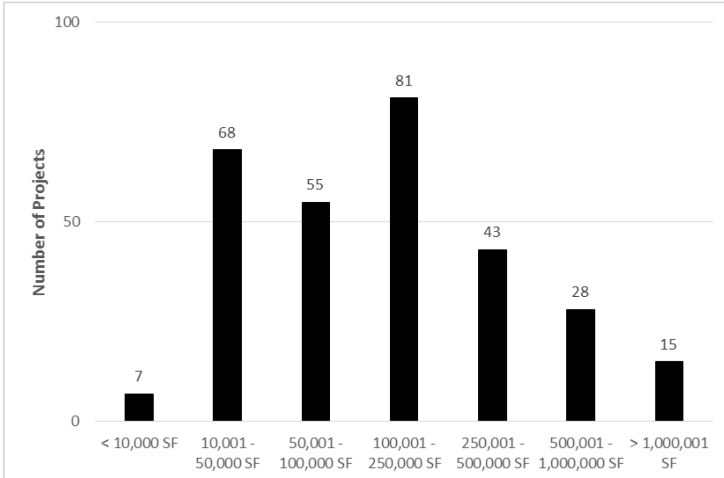


Figure 4 – Number of DB projects for each size group completed from 2004-2013

## *Analysis*

After all the relevant information was extracted from the DBIA database, the performance of the projects were compared in terms of schedule and cost (see Table 1). Among 367 projects (performance information for all the projects were not available in the database), only 25% were delivered past the proposal completion date. The rest were either finished on schedule or ahead of the proposal completion date. In contrast, almost 60% of the projects suffered from cost overruns compared to the proposal budget. For the purpose of calculating schedule overrun and cost overrun, the authors have compared the actual numbers with the proposal schedule and cost information. This appears to align with the findings of Tran and Molenaar (2014) that project owners select the DB method to take advantage of potential time savings the process yields, albeit with increase risks and uncertainties in the projects due to concurrent design and construction activities. Other studies indicate that owners choose to implement DB for reduced overall schedule as the primary benefit, while cost savings were a less motivating factor (Lopez del Puerto et al. 2008).

Table 1: Summary of DB project performance from 2004-2013

| | **On Time** | **Schedule Shortened** | **Schedule Overrun** | **On Budget** | **Cost Saved** | **Cost Overrun** |
|---|---|---|---|---|---|---|
| Number of Projects | 99 | 176 | 92 | 76 | 78 | 223 |
| Percentage | 26.98% | 47.96% | 25.07% | 20.16% | 20.69% | 59.15% |
| Total | 367 Projects | | | 377 Projects | | |

Based on the data available, the authors attempted to understand the annual variations in schedule and cost growth for the DB projects. The annual variations are shown in Figure 5, which illustrates the fluctuations over the six year period from 2006 to 2012. While the extracted data contain projects completed prior to 2006 and after 2012, the numbers are extremely small and the authors did not include them in the analysis. The schedule and cost growths shown in Figure 5 are the averages of the projects completed in those particular years. As evident from the graph, the schedule growth showed incremental improvement over the years, while the cost growth does not show that much of improvement.

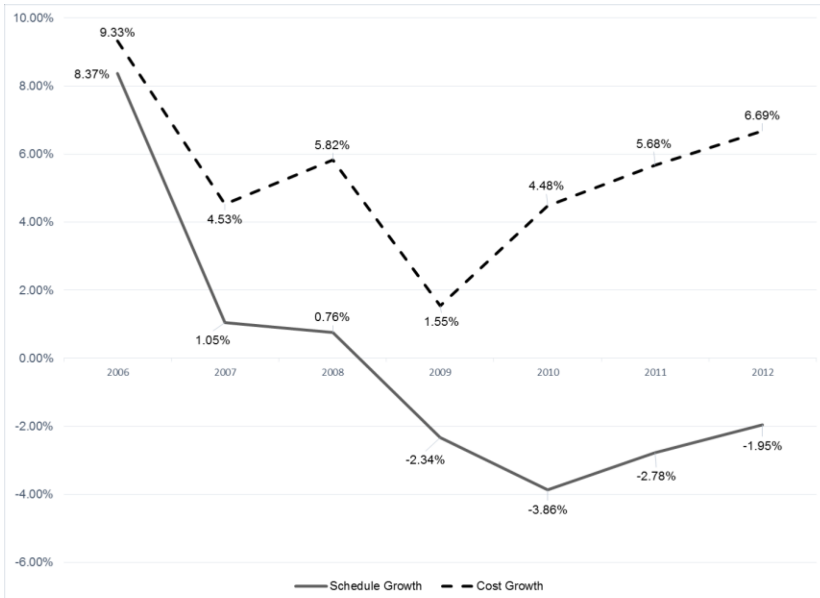


Figure 5: Schedule and Cost Growth Change from 2006 to 2012

Projects in civil, educational, government, industrial, medical, military, and water & sewer categories were segregated to find the trend in their schedule growth and cost growth. Figure 6 shows average schedule growth and average cost growth of each building category. The medical category demonstrated the least schedule growth, which means the medical projects resulted in the greatest time savings. It is followed by the civil category with -4.63% and government projects with -3.15%. The industrial category was the only one without any reported schedule growth. None of the building categories could achieve cost savings.

However, most building categories including civil, educational, government, industrial, and water & sewer marked average cost growth less than the average of the entire project database. Surprisingly the military category presents an average cost growth of 22.71%. This finding is not in accordance with Fox's (2006) claim that the typical DB project goal of U.S. Air Force is to achieve a cost growth of less than 5% and schedule growth of less than 10%. On further investigation, the authors found that 83% of the projects in the military category were found to experience cost overrun. Table 2 below shows the details of the DB projects based on their categories. Current analysis revealed that all projects in the medical category were completed by the proposal completion date. This reflects a superior performance compared to all other categories. Among seven categories, the medical sector delivered the greatest amount of projects on time or earlier, followed by the educational and industrial sectors. The industrial category contained the highest amount of projects completed within budget or below, followed by the water & sewer and medical sectors. Some of the findings warrant further detailed investigations to identify the root causes that can lead to interesting future studies.

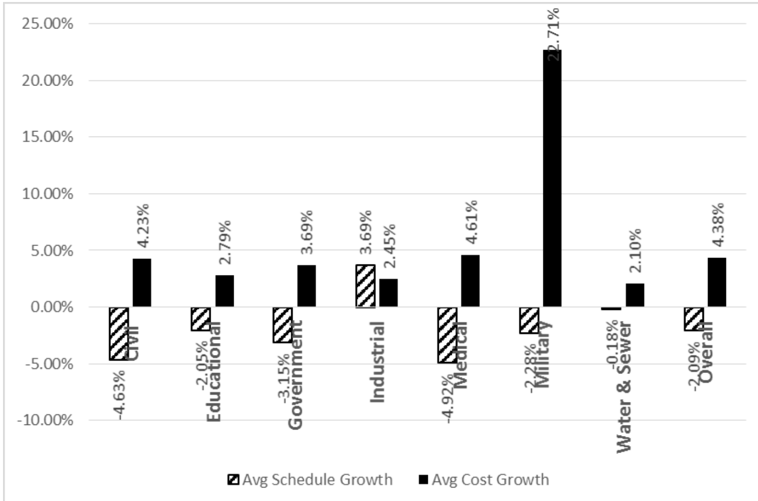


Figure 6: Schedule and cost growths in building categories

Table 2: Detailed schedule and cost growth in building categories

| Building Category | On Time N(%) | Schedule Shortened N(%) | Schedule Overrun N(%) | On Budget N(%) | Cost Saved N(%) | Cost Overrun N(%) |
|---|---|---|---|---|---|---|
| Civil | 8 (27.6) | 15 (51.7) | 6 (20.7) | 9 (29) | 1 (3.2) | 21 (67.7) |
| Educational | 18 (29) | 33 (53.2) | 11 (17.7) | 6 (9.7) | 17 (27.4) | 39 (62.9) |
| Government | 4 (14.8) | 14 (51.9) | 9 (33.3) | 7 (24.1) | 5 (17.2) | 1 (58.6) |
| Industrial | 13 (37.1) | 15 (42.9) | 7 (20) | 14 (40) | 11 (1.4) | 10 (28.6) |
| Medical | 7 (30.4) | 16 (69.6) | 0 (0) | 5 (21.7) | 8 (34.8) | 10 (43.5) |
| Military | 14 (21.5) | 31 (47.7) | 20 (30.8) | 8 (12.3) | 3 (4.6) | 54 (83.1) |
| Water & Sewer | 11 (22) | 22 (44) | 17 (34) | 10 (18.9) | 20 (37.8) | 23 (43.4) |

Beard et al. (2001) pointed out that the size of a project must be sufficiently large in order to justify the risk to potential reward. Also, the project must be complex enough to draw collaborative efforts between involved professional parties (Beard et al. 2001). Although less schedule growth was expected in larger projects, projects smaller than 10,000 square feet outperformed projects in the larger size groups. The exceptions are the projects above 1,000,000 square feet, as shown in Figure 7. In addition, projects groups up to 10,000 square feet had the lowest average cost growth. It may be interpreted that smaller projects do not have as many uncertainties in design or decision making as compared to larger projects with complex scope, but are able to exploit the advantages of time saving due to overlapping phases of the project.

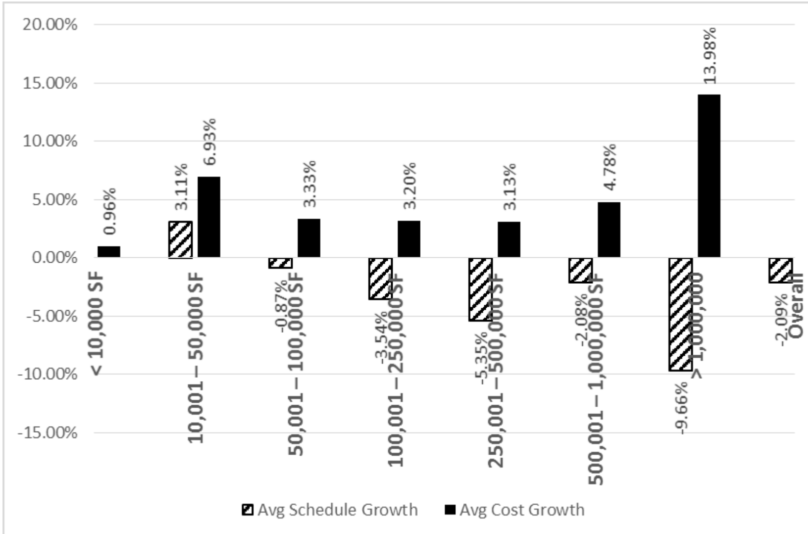


Figure 7: Schedule and cost growths in building sizes

## Conclusions

The DB method has been utilized for decades, but was previously referred to as a single source approach known as the 'master builder'. There exist a need for examining how DB projects perform in regards to schedule and cost, in order for the construction industry to improve the DB implementation as well as productivity in general. When the DB method is used properly with active collaboration between key stakeholders, projects could be delivered on or before the proposed completion date with possible cost savings (Hale et al. 2009). A total of 407 projects were studied in this paper to quantitatively determine the performance of the DB delivery method. Schedule growth and cost growth were used as variables to measure performance level of specific project groups. As a whole it was found that projects achieved reduced schedule growth but experienced increased cost growth. Among the different building categories, the medical sector displayed superior results in schedule growth, with minimal delays in the project completion. The water & sewer category had the lowest average cost growth of 2.1%. The military sector did not perform well in terms of budget, indicating a need for further investigation for to determine potential causes. No significant correlation was found between project size and level of performance.

The objective of this study was to provide a better understanding of the DB delivery method and enrich the knowledge of best practices of the DB method. However, the results of this study are limited due to the specialized nature of construction projects. A qualitative study, such as in-depth case studies and interviews in each building group, would be the next step to further investigate the performance of DB projects.

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