THE PERFORMANCE OF PROGRESSIVE DESIGN BUILD PROJECT DELIVERY METHOD

by

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DEDICATION

This is dedicated to my mom, my loving husband Haider Shaghati, and my three wonderful children Hasan, Maryam, and Dania.

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LIST OF ABBREVIATIONS AND SYMBOLS

Progressive Design Build ....PDB

Guaranteed Maximum Price ....GMP

ABSTRACT

THE PERFORMANCE OF PROGRESSIVE DESIGN BUILD PROJECT DELIVERY METHOD

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In the past few years, the Progressive Design Build (PDB) delivery method began gaining traction in the construction industry. PDB projects have been shown to be successful specifically for water/wastewater and transportation projects. However, as far as owners are concerned, two main questions still remain unanswered: (1) What are the best practices to maximize the likelihood of success in PDB projects? (2) Under which circumstances should one be using PDB as a delivery method? While owners need to understand the factors that govern project performance and the factors that impact selection of delivery methods, there is no empirical database to provide evidence for efficient decision making.

Therefore, to fill this gap in the literature, this study aims to examine the impact of time of involvement, team selection, team behavior, and trust on the performance of projects delivered using the PDB method and to determine the importance of variables that impact an owner's decision to select PDB as a delivery method for a project. This thesis reports on an empirical investigation of the performance and characteristics of projects delivered using the Progressive Design Build method by establishing a database of completed PDB projects and conducting a descriptive and multiple statistical analysis using the Mann-Whitney U test. The significant results of the statistical analysis provide a list of best practices owners can follow to increase their chances of achieving success in PDB projects. For example, to reduce the severity of disputes in a project, it is better to wait to set the guaranteed maximum price (GMP) when the design has developed more than 60 percent. In addition, this study identified and prioritized influential variables in selecting PDB as a delivery method. This study contributes to both academia and practice. As far as academia is concerned, this study is the first attempt to establish a performance database of PDB projects. Practitioners also can benefit from the results, which identify best practices for maximizing success in PDB projects and provide guidelines for using PDB as a delivery method, based on owner and project characteristics.

INTRODUCTION

One of an owner's early decisions that has significant impact on project success is selection of a delivery method. Several studies have compared performance of different delivery methods in terms of cost, time, quality, and disputes (Molenaar and Songer 1998a; Chan et al. 2001a, 2002; Ibbs et al. 2003; Ling et al. 2004a; Ling 2004; Ling et al. 2004b; Li et al. 2005; Menches and Hanna 2006; Lam et al. 2008; Rojas and Kell 2008; Ling et al. 2008; Hale et al. 2009; Minchin et al. 2010; Molenaar and Navarro 2011; Shrestha et al. 2012; Esmaeili et al. 2013; Mollaoglu-Korkmaz et al. 2013; Park and Kwak 2017; Hasanzadeh et al. 2018a). One of the emerging delivery methods that has gained traction in the past few years is progressive design-build (PDB). PDB offers an initial design and construction package, which can benefit the owner during price negotiations to reduce and influence the progressive estimation of the project budget (Gransberg and Molenaar 2019). This package also can provide an early warning to owners when the project's estimated cost exceeds the project budget so they can control it by making changes to reduce increasing costs (Gransberg and Molenaar 2019). One of the essential benefits of PDB is the ability to make early changes in the project to reduce risk by relying on real project information.

PDB projects have been shown to be successful, especially for water/wastewater and transportation projects. However, as far as owners are concerned, two main questions still remain unanswered: (1) What are the best practices to maximize the likelihood of success in PDB projects? (2) Under which circumstances should one use PDB as a delivery method? While owners need to understand the factors that govern project performance and the factors that impact selection of delivery methods, there is no empirical database to provide evidence for efficient decision making. Therefore, to fill this gap in the literature, this study aims to: (1) test the impact of time of involvement, team selection, team behavior, and trust on performance of projects delivered using PDB method and (2) determine the importance of variables that impact the owners' decision to select PDB as a delivery method for a project. This research offers owners insights about factors that govern and affect project performance. It is also an important tool to support owner decisions in selecting the most appropriate delivery methods for maximizing the likelihood of success. This thesis includes an introduction and five chapters:

1. *Background*: This chapter covers all salient literature regarding the project delivery performance measures and limitations in the current body of knowledge.
2. *Research method*: This chapter concerns research activities that were conducted to accomplish research objectives. First, a performance database of completed PDB projects was developed by designing and distributing an online questionnaire and collecting responses. Second, multiple statistical analyses were conducted to test the impact of independent variables (e.g., team behavior) on project performance (e.g., cost growth). Third, an online questionnaire was developed and distributed, and responses were used to measure the importance of factors affecting owners' decisions to select PDB as a project delivery method.

3. *Results*: In this chapter, a descriptive analysis of the performance database is reported, and the results of inferential statistical analyses are presented.
4. *Discussion*: This chapter focuses on implications of the statistically significant relationships between influential variables and project performance metrics.
5. *Conclusions*: This chapter summarizes research findings and provides recommendations for academia and practitioners.

CHAPTER ONE: BACKGROUND

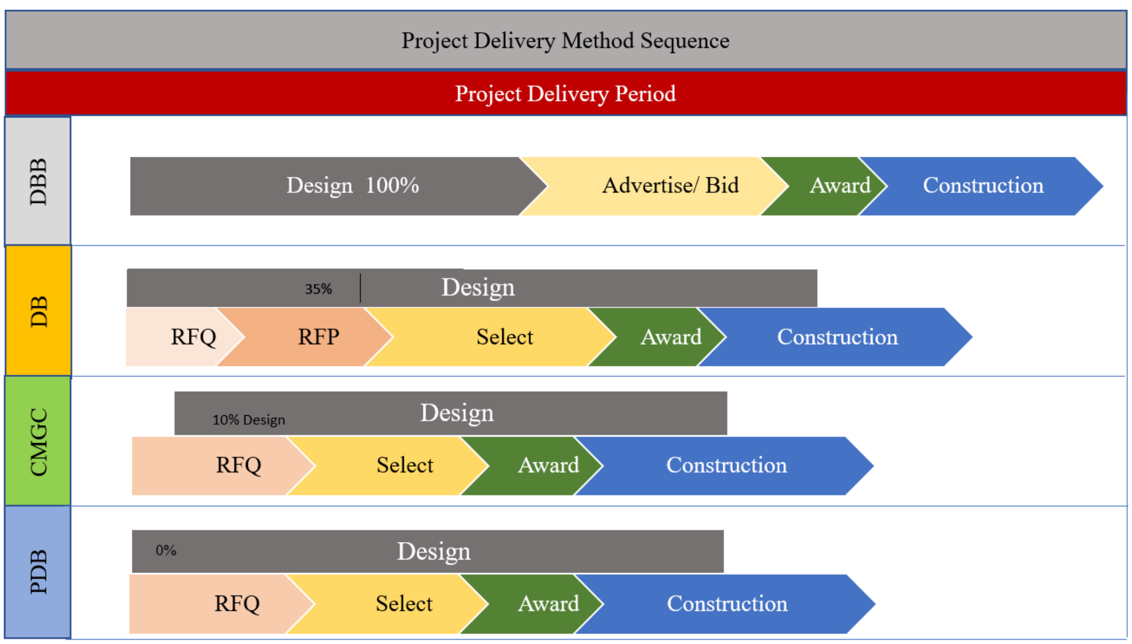
What is Progressive Design Build (PDB)?

Progressive Design Build is one model of a design-build (DB) delivery method in which the owner hires the design-builder at the early stage of the project, even before developing the project design, then moves forward to procure the project with a progressive construction estimation and contract prices. This method builds great team collaboration and trust, which works on owner's behalf. In this type of contract, the owner selects the design-builder based on qualifications or best value; typically, the cost and schedule commitment are not part of this selection process (DBIA 2017).

This stepped method allows the owner to capitalize on the advantages of design-build and construction management at risk (CMAR) delivery methods (Brown and Caldwell 2016), by offering a single contract (DB) and retaining the design-builder at early stages of the project to identify, allocate, and manage risks (CMAR). Both advantages provide the owner with maximum control by using progressive estimating for schedule and budget, the open book estimating process, and flexibility to make changes during the design phase, which are the most critical factors for project success.

This design-build model is done in two phases. The first phase is the preconstruction services, where the design-builder, his/her consultant, and the owner work together with high coordination to achieve project success. They create, improve, and confirm the design, project programming, cost, schedule, quality, and other project issues to advance a design that fits with owner requirements. At this point, the design-builder establishes the contract price and negotiates either GMP or lump sum for phase two.

Phase two starts after the owner and design-builder agree on commercial terms. The design-builder will then complete the final design and construction services. If the owner and design-builder do not agree on phase two, then the owner may consider the "off-ramp" option, where the owner can use the design for phase one and move with another contract strategy. The process is compared with other delivery methods illustrated in Figure 1.



DBB= Design Bid Build, DB= Design Build, CMGC= Construction Manger/General Contractor, PDB= Progressive Design Build

Figure 1. Project Delivery Method Sequence (adapted from Gransberg and Molenaar 2019).

Owners may consider Progressive Design Build for the following reasons:

- Reduces the overall project cost and schedule because PDB offers progressive construction estimation (open-book environment) for project scope, cost, schedule, and quality during the design improvement stage (phase one).
- Maximizes owner control of the design inputs and decisions that affect project scope, quality, cost, and schedule.
- Offers great collaboration between the owner and the design-builder.
- Reduces the time for the owner (owner risk) to review and act upon design submittals, because design is completed during phase one.
- Enhances the procurement process, giving the owner a chance for early work packages, and reduced schedule.
- Allows the owner to collaborate in selecting subcontractors and suppliers.
- Provides an "off-ramp" option if the owner does not agree on the commercial price that the design-builder provides.

CHAPTER TWO: LITERATURE REVIEW

Performance of Design-Build (DB) Projects

Chan et al. (2001a) conducted a study to identify critical factors that contribute to successful design-build projects, focusing on the duties, responsibilities, and capabilities of project participants, including clients, contractors, end users, architects, and design consultants. To achieve this objective, the authors considered 31 successful factors from the literature and participants' opinions from a questionnaire survey. They used principle factor analysis to reduce those 31 factors to six main success factors: project team commitment, contractor's competencies, risk and liability assessment, client's competencies, end users' needs, and constraints imposed by end users. Results from this analysis showed that the three highest factors affecting project outcomes are, in descending order: team commitment (comprising factors such as trust, good work relationship, open-mindedness, cooperation); client's competencies (including clear client brief and no conflict or ambiguity in developing design); and contractor's competencies (including the contractor's technical capability and understanding of the design process).

The authors used two independent sample t-tests to examine the relationship of these six factors with project performance (i.e., time performance). They found that the contractor competency factor had a significant difference mean rating in contrast with the other five factors. Therefore, the authors recommended that design-build project owners should pay more attention to the contractor's design management capabilities and experience during the evaluation process. Additionally, a relationship was found between project performance and project participants' satisfaction. Good design-build time performance was associated with participant satisfaction about time, but it was surprising that there was no association between cost performance and participants' satisfaction with cost. Thus, the authors recommended that project stakeholders should focus on overall project performance, including such factors as time, cost, quality of design, and workmanship, rather than a single performance factor, because clients may not be satisfied even if a project finishes below budget but overall performance is of poor quality. The findings of these multivariate analyses create a foundation and useful tool for successful design-build projects.

In another study, Ling (2004) identified 11 significant variables that affect project performance and developed models to predict the project performance for DBB and DB projects using a limited number of variables that impact project performance. Reviewing the past research, the authors identified 59 potential factors that affect project performance and categorized them into three groups: project characteristics, owner and consultant characteristics, and contractor characteristics. They then determined the most critical factors that affect project performance by distributing questionnaires among projects over $5 million in value in the Singapore Building and Construction Authority. Using multivariate regression analysis, the authors developed 11 models to predict performance of DBB and DB projects. It was found that owner satisfaction for DBB required a contractor with high staffing levels, and for DB, a contractor with good quality performance on past projects.

Influential Factors in Selecting Delivery Methods

Previous studies have shown that selecting a different organizational structure can have significant impact on project success (Gordon 1994; Love et al. 1998; Molenaar and Songer 1998b; Al Khalil 2002; Thanh Luu et al. 2003; Ling et al. 2004a; Luu et al. 2005; Mahdi and Alreshaid 2005; Mafakheri et al. 2007; Mostafavi and Karamouz 2010; Touran et al. 2011; Chen et al. 2011; Tran et al. 2013; Qiang et al. 2015a; b). Considering that there is no single best organizational structure, several combinations of delivery method, team selection process, and contracting type can be appropriate for a project. In one early attempt to select project organization based on certain types of owners and projects, Gordon (1994) developed guidelines using the process of elimination to help owners select project delivery, team selection, and contracting methods based on the limited variables available at the beginning of the project. The suggested process starts by eliminating inappropriate alternatives that do not satisfy owner or project needs. To eliminate unsuitable delivery methods, Gordon (1994) suggested that owners assess three types of characteristics (drivers) as shown in Table 1. If there is no single organizational fit to project drivers or more than one organization is suitable for project drivers, then the owner and market drivers will help reduce the remaining results. Owner drivers are more accurate than project drivers because they depend on the owner's judgments. Market drivers help owners understand the industry environments and availability of contractors.

Table 1. Important drivers in selecting project delivery method

Project drivers	Owner drivers	Market drivers
• *Time constraints* • *Flexibility needs*: amount of flexibility because of project size and complexity • *Preconstruction service needs*: importance of cost estimation, constructability reviews, and value engineering • *Design process interaction*: importance of innovation, appearance, or function • *Financial constraints*	• *Construction sophistication*: type of skills and experience needed from owner, staff, and administrative resources • *Current capability*: level of involvement required from owner • *Risk aversion* • *Restrictions on methods*: some public owners are prohibited from using certain types of delivery methods • *Other external factors*: strategic or political reasons	• *Availability of appropriate contractors* • *Current state of the market*: competitiveness of the market • *Package size of the project*: ability to attract competitive contractors

After selecting the project delivery methods, owners must decide about the contracting method. In Gordon's (1994) view, risk management is the backbone of any contracting selection. Owners should use a method that helps them assess, allocate, and manage risk successfully. Finally, to choose an appropriate team selection approach, Gordon (1994) suggested that after considering any regulatory restrictions, owners should separate processes for awarding contracts for commodities and services; while commodities contracts should be awarded solely on price, other factors (e.g. qualifications) can be considered for awarding service contracts.

To develop a mechanism for successfully selecting public projects that are suitable for the design-build method, Molenaar and Songer (1998b) used multi-attribute analysis and a retrospective case study to predict models that fit all construction projects. From the multi-attribute analysis, they developed a hierarchy of 44 project characteristics that affect project success. After measuring all 44 variables, they grouped them under four main categories: project, owner, market, and relationship. Subsequently, those characteristics became the basis for data collection. Project size was valued from $29,000–$780,000,000; project construction types were building, highway, and industrial; agencies were federal, state, and local. Of the projects they reviewed, 75% were federal projects and 82% were building projects. Therefore, federal building projects predominated in their study.

The authors analyzed the collected data using multiple regression analysis; independent variables included project, owner, market, and relationship; dependent variables included budget variance, schedule variance, conformance to expectations, administrative burden, and overall user satisfaction. Based on the dependent variables, five regression models were created for selecting a successful design-build project. The significant finding of the analysis showed that 26 of the 44 predicted variables were important in one or more of these five regression models, and those findings were confirmed with examinations of past research.

In summary, it was found that:

- Projects with minimum information in the RFP and a clear definition of the owner's goals encourage the design-builder to be innovative in the RFP phase.
- Projects with schedule-driven characteristics need more efforts from the owner during RFP development. For example, the owner needs to write a fixed completion date in the RFP to give the design-builder enough time to respond and give the owner time to review and answer questions.
- For cost-driven projects, the design-builder will deliver the project with less cost growth, but the satisfaction of users or owners may not be guaranteed.
- For projects requiring complex design and construction, compressed schedule design-build performs better than other delivery methods.
- A surprising result of this research is that owners with more experience in design-build projects face lower project performance because, when owners gain design-build experience and become more familiar with DB, they might make early decisions without looking to circumstances or problems that might occur.
- Owners should lower their contingency and become more restrictive regarding the project scope, make early decisions during the design phase, and discourage additions in the RFP phase or give contractors the chance for creativity.
- Completing the project design before engaging the design-builder will result in poor project performance. On the other hand, after hiring a design-builder, the owner should take a hands-offs approach to increase the chance of success.
- Design-builders perform better with performance specifications because they have room for creativity.

- Qualification of the best selection works better with design-build and produces better performance because the design-builder is involved early in the project and can govern the project's scope, cost, and schedule, thus reducing the administrative burden.

Lessons learned from Molenaar and Songer's study can be used as an improvement tool for public sector organizations to support their decision making and achieve successful design-build projects.

Touran et al. (2011) conducted a study to determine influential factors in selecting the best delivery methods for transit projects. The authors identified 24 factors that impact early decisions in selecting delivery methods in transit projects by conducting a comprehensive literature review and validating a preliminary list of factors using case studies and structured interviews. The four reasons most frequently stated by interviewees for selecting a given project delivery method are reducing project delivery period; encouraging innovation; establishing a project budget at an early stage of design development (i.e., cost certainty rather than cost saving); getting early contractor involvement; and providing flexibility during the construction phase. Identified factors were categorized into five groups:

- *Project-level issues*: project size/complexity; cost; schedule; risk management; risk allocation; and LEED certification
- *Agency-level issues*: agency experience; staffing required; staff capability; agency goals and objectives; agency control of project; and third-party agreement

- *Public policy/regulatory issues*: competition; disadvantaged business enterprise (DBE) impacts; labor unions; fed/state/local laws; FTA/EPA regulations; and stakeholder/community input
- *Life cycle issues*: life cycle costs; maintainability; sustainable design goals; and sustainable construction goals
- *Other issues*: construction claims and adversarial relationships.

The findings described in this paper can enhance the project delivery selection process for transit projects.

In another study, Qiang et al. (2015) conducted a content analysis of past literature to identify factors governing construction project delivery selection. They conducted a principal component analysis on the relative importance of these factors obtained from experts in China and other developed countries to identify underlying factors, including:

- *Internal condition factors*: client's ability, client's preference
- *External project condition factors*: contractor related factors, consultant related factors, project characteristics, external project environment
- *Performance objective factors*: project process performance, project outcome performance.

They used the data extracted to further evaluate these factors in their research. To compare whether the relative importance of factors was significantly different between China and other developed counties, they conducted a T-test. They found perspective divergences between China and other developed countries according to the frequency with which each factor was emphasized by respondents. It was also revealed that project complexity and size were the most influential factors for external project conditions in

China because they related to organizational complexity and its contribution to project risks, which affected all parties. On the other hand, ownership and regulation were the most important external factors considered by experts in other developed countries. Finally, this study provides quantitative and comprehensive perspectives from practitioners in China and developed countries and becomes a basis for providing governing factors for the selection process. Further research can focus more on how to utilize those governing factors in the selection process.

The literature review resulted in a list of factors that influence selection of project delivery methods. In total, 25 factors were identified and later used in a data collection instrument to determine the relative importance of these factors in selecting PDB as a delivery method.

Application of Multi-criteria Decision Analysis (MCDA) Techniques

In addition to identifying influential factors in selecting the best delivery system, some other researchers have used Multi-criteria Decision Analysis (MCDA) techniques to select the best delivery system for a project. To provide a structured system for owners to choose the appropriate project delivery method, Al Khalil (2002) suggested using the analytical hierarchy process (AHP) model because it simplifies a complex problem by breaking it down into sub-problems in a hierarchy structure. With the AHP model, the decision maker needs to evaluate the relative importance of each factor and apply pair-wise comparisons for all sub-factors on the same level by utilizing a weight scale. These comparisons should be accomplished in regard to the overall project objectives. After finishing the evaluation and comparison, each factor at the same level is ranked and prioritized. When completing the aggregation process for ranking and prioritization, the high-priority project delivery method should be selected. This AHP model can help users determine the factors directly involved in choosing the best project delivery method in addition to selecting the appropriate project delivery method. The hierarchy design for selecting the project delivery methods proposed in this study is presented in Figure 2.

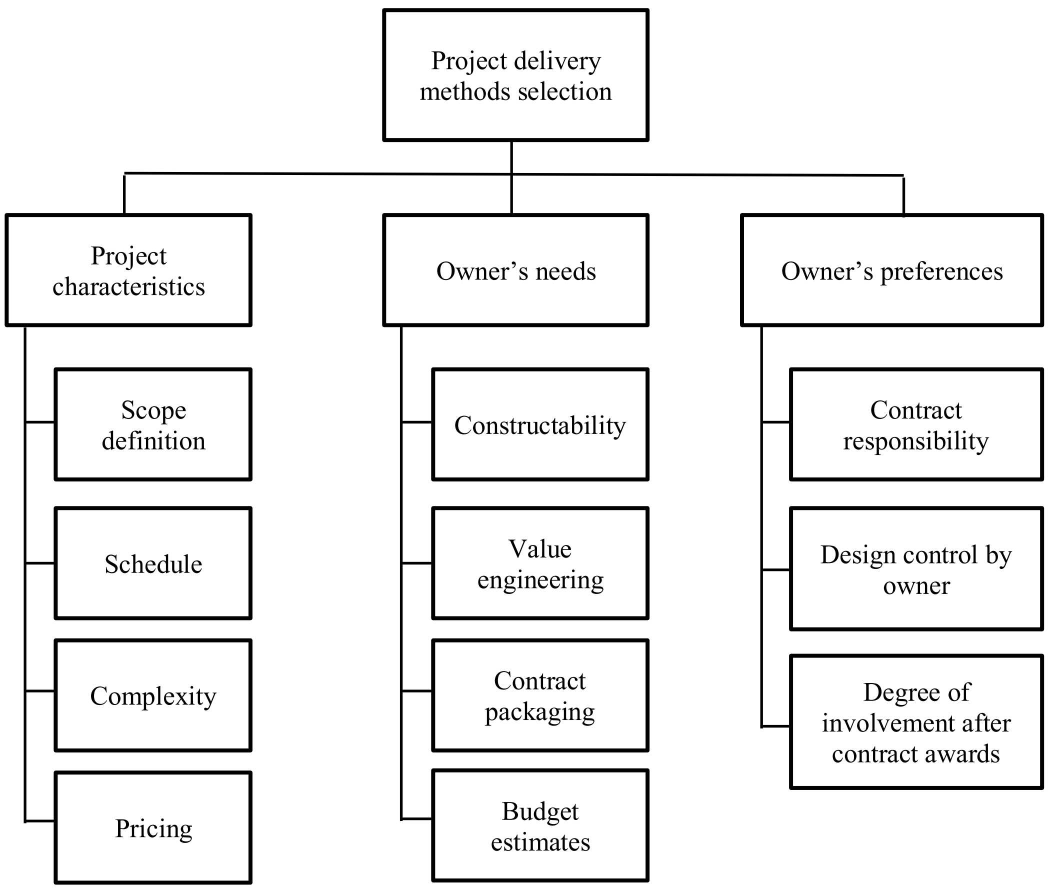


Figure 2. Hierarchy design for the project delivery method selection model, adapted from Al Khalil (2002).

In another study that used the AHP technique, Mahdi and Alreshaid (2005) studied the compatibility of different project delivery systems with certain types of owners or projects. They claimed that the following three main factors help determine project delivery options: (1) Are the design and construction processes linear, or are they combined?; (2) Is the construction cost of work the main focus? and (3) Is the total cost the main focus? In reviewing the existing literature, the authors identified 34 factors grouped in seven factor areas: owner characteristics, project characteristics, design characteristics, regulatory factors, contractor characteristics, risks, and claims and disputes. Afterward, the researchers conducted 16 interviews with experts from the construction industry to identify the relative importance of these factors, and they used AHP to decide their relative importance and prioritize them. They also used sensitivity analysis to modify this prioritization. They found that when the primary considerations for a project are flexibility of design performance, shortening the project duration, risk management, and reducing claims and disputes, the DB delivery method would be the best option, followed by CMA and DBB, respectively.

Oyetunji and Anderson (2006) provided a quantitative evaluation for identifying alternative project delivery systems based on multi-criteria analysis of decision problems, including decomposition of decision problems and aggregation of solution problems using several analysis techniques. The authors considered several analytical techniques to support decision making in assessing alternative project delivery systems and finally settled on Multi-criteria Decision Analysis (MCDA) as a fitting technique for selecting project delivery systems. This study claims that the simple multi-attribute rating technique with swing weights (SMARTS) is an appropriate quantitative evaluation process for selecting a project delivery system. Using SMARTS, the authors identified 12 alternative project delivery methods and three selection factors of importance to owners, including completion of the project within budget, completion of the project at the earliest time, and confidentiality of project documents. The authors demonstrated application of the technique with a case study and claimed that this quantitative analysis process for selecting alternatives helps project managers and enhances the process of decision making to achieve the optimal solution.

Uncertainty related to influential factors and the existence of multiple criteria make selection of a project delivery system a complex decision-making process. While using AHP enables decision makers to model a problem in a structured fashion, it still has a major limitation due to uncertainty related to the judgments of individual experts. Imprecise assessment of weights can result in uncertain ranks for project alternatives. To address this limitation, Mafakheri et al. (2007) suggested using an AHP interval model coupled with an optimization procedure that uses interval instead of single-point assessment to better deal with uncertainties. When there are incomparable alternatives, Mafakheri et al. (2007) recommended using rough-based set measures to select the number of decision criteria that enable ranking of alternatives. Factors they considered in their model include cost, schedule, quality, complexity, scope change, experience, value engineering, financial guarantee, risk management, uniqueness, external approvals, project size, and culture. To determine the interval weights of alternatives, pairwise comparisons were conducted followed by upper and lower linear programming modeling to prioritize intervals. In order to support this prioritization and come to a final decision, a rough set theory was developed to find new rankings and remove other determinations of alternatives.

Chen et al. (2011) highlighted inadequacies in previous project delivery system selection techniques. The Analytical Hierarchy Process (AHP) model relies on expert judgment to assess the weight of influential variables, which may lead to inaccurate results. In addition, conducting pairwise comparisons for a large number of indicators is not practical. Regarding multi-attribute utility techniques, the utility values of indicators do not represent the actual status of the project. To overcome those shortcomings and develop a more accurate and efficient project delivery system selection method for China, Chen et al. (2011) suggested an approach that relies on comparing similarities of projects that are going to be delivered with projects existing in the database, modifying the similarity indicators using the data envelopment analysis (DEA)-bound variable (BND) model, and then training the artificial neural networks (ANN) model to select the best delivery method. DEA helps avoid potential subjective biases introduced by experts, and the ANN has a self-adjustment capability that eliminates the need to collect weights like other methods of selections (e.g., AHP). To demonstrate applicability of the model, Chen et al. (2011) identified 16 project delivery system selection indicators from the literature review and categorized them under four groups:

- *Project objectives*: schedule delay, cost growth, project quality
- *Project characteristics*: project type, project scale, project complexity, project flexibility, disputes
- *Characteristics of owner and contractor*: owner's willingness to be involved, available personnel, willingness to take risk, contractor's capability
- *External environment*: market competitiveness, regulatory feasibility, technology availability.

A questionnaire survey was distributed to collect project data and establish a project delivery selection database. To increase the accuracy of ANN, the authors used DEA-BAND to evaluate the owner's management efficiency among construction processes. In order to apply DEA-BAND, the input indicator values were specified by a fuzzy triangular number including one probable and two boundary variables that were identified from the questionnaire. The authors then applied back propagation ANN to train and predict the targeted projects for project delivery selection. The validation process showed that the prediction model is more reliable than the ANN model alone.

Use of complicated decision-making methods, such as the analytical hierarchy process (AHP) and artificial neural network (ANN), makes it difficult for practitioners to follow suggested approaches in day-to-day operations. To address this limitation, Tran et al. (2013) developed a selection matrix to support and compress the highway decision process for selecting the proper alternative delivery method. The authors identified factors that affect project delivery selection using a literature review and conducting workshops with owners and contractors' representatives. The research team identified eight critical selection factors through this process and grouped them into two groups: (1) primary selection factors (delivery schedule; project complexity and innovation; level of design; initial project risk assessment) and (2) secondary selection factors (cost; staff experience and availability; level of oversight and control; competition and contractor experience). The primary factors – except risk assessment – are used to select an appropriate delivery method, and the secondary factors need to be satisfied (pass/fail). During the workshops, the authors also asked panelists to identify the barriers and opportunities for three delivery system alternatives (i.e., DBB, DB, and CMAR) by considering project conditions and restrictions. The proposed highway selection matrix contained three stages:

1. Identify project goals and project limitations to find out which delivery method is suitable.
2. Assess each delivery option by considering the four primary factors.
3. Conduct risk assessment to define the appropriate project delivery method, then pass-fail analysis by evaluating secondary factors.

This matrix provides a checklist of general challenges and opportunities as a reference for all delivery methods to help decision-makers understand procurement methods, construction administration, and project risk, while not missing any project issues. This study also presented a case study from the Colorado DOT to examine this matrix, and the results of using this approach could effectively help determine the appropriate highway delivery method. Further research can be done by adding to this matrix – for example, by choosing the proper procurement method for highway projects.

It is notable that developing a decision-making algorithm to select the best delivery method for a specific project is out of the scope of this thesis. However, reviewing literature about MCDA techniques provides guideline for future research studies that can be built upon findings of the current study.

CHAPTER THREE: METHODOLOGY

The objectives of this study were to (1) test the impact of time of involvement, team selection, team behavior, and trust on performance of projects delivered using the PDB method and (2) determine the importance of variables that impact the owner's decision to select PDB as a delivery method for a project. The research objectives were achieved in three distinct phases. In the first phase, the research team developed a performance database of completed PDB projects by designing, distributing, and collecting responses to an online questionnaire. In the second phase, multiple statistical analyses were conducted to test the impact of independent variables (e.g., team behavior) on project performance (e.g., cost growth). Finally, an online questionnaire was developed and distributed and responses were collected to measure the importance of factors affecting owners' decisions to select PDB as a delivery method for a project. The following sections discuss the details of the research methods employed in these three phases.

Phase I: Developing a Performance Database of Completed PDB Projects

A questionnaire consisting of six different sections was developed and distributed to professionals (i.e. project managers) in the construction industry across the United States who had experience with PDB projects. The questionnaire collected participants' personal information and asked them about project characteristics, team procurement and contracts, team behavior and communication, and project performance (e.g., cost growth), followed by open-ended questions to let participants talk about their PDB experiences.

In the first section, participants were asked about the state in which they were employed, the type of organization at which they were employed, years of experience, and the group or section in which they worked (i.e., design, construction, operation, alternative project delivery group, contracts/procurement, materials, and others). In the second section, participants were asked to identify the type of construction project they had worked on, and to specify the level of design complexity, construction complexity, and overall success of the project using a Likert Scale from (1= low to 5=high). Respondents were also asked to select the time in the process when the design-builder contracted for the project (e.g., pre-design).

In the third section, participants were asked about the method by which project proposals were solicited from the design-builder (i.e., open bid, qualification, 1-stage RFP, 2 stage RFP, and sole source), and they were asked to rank factors that impacted the selection of the design-builder (i.e., price, technical proposal, design concept, similar project, experience, interview performance) using a Likert Scale (1=most important to 5= least important). This section also included questions asking about the percentage of design completion when the GMP was put in place, whether there was a contingency term on the contract, and whether a third party was used to verify the price. Further, this section included questions regarding satisfaction with the design process, construction process, and negotiation of the GMP process, as well as questions asking about the frequency of claims that arose at the field level, the severity of claims that arose on the project in terms of time to resolve them, and the severity of claims that arose in terms of cost impact. Responses to these questions were collected using five-point Likert Scales.

The fourth section of the questionnaire included questions about the team behavior and communication: the type of relationship between the owner and the design-builder (i.e., first time, and repeat); use of a formal partnering agreement by the project team; upper managerial support for the design-builder and responses; the quality of input shared during the projects' preconstruction phase; the team's prior experience as unit; formality of communication among team members; timeliness of communications; electronic files and information sharing used by the project team; and risk identification and allocation. Also, respondents were asked to evaluate the levels of trust (competency, organizational, and relational) between their organization and the design-builder.

The fifth section posed questions about project costs (i.e., original contract price and percentage of cost growth) and schedule (i.e., original duration and percentage of schedule growth), and questions to compare the cost, schedule, and quality performance of projects delivered using PBD with projects delivered using traditional design-build (lump sum).

In the last section of the questionnaire, respondents were given the opportunity to express their opinions about the most important reasons to use or not to use PDB as an alternative method, under which circumstances they recommend using PDB to deliver a project, and any lessons they learned on this project. Before finishing the questionnaire, respondents were asked if they would be willing to be contacted for a follow-up survey.

After developing the questionnaire, it was pilot tested among practitioners and academics for commentary. The questionnaire was modified according to the comments received. Then, the questionnaire was distributed among 68 professionals in the construction industry across the United States who had experience with PDB projects. The process was approved by the George Mason University Institutional Review Board.

In total, 23 out of 68 participants responded to the questionnaire and shared information about their progressive design-build (PDB) projects. Respondents, on average, had 32 years of experience in the construction industry (median=35 years) and held top management positions including presidents, vice presidents, senior vice presidents, directors, and professional engineers. Types of projects were water/wastewater, highways, airports, and freight rail transportation. The collected data was analyzed in the next phase.

PHASE II: CONDUCTING STATISTICAL ANALYSIS

One of the objectives of the study was to measure the effect of variables such as project characteristics, team selection, and team behavior on performance of PDB projects to determine best practices that increase likelihood of success in these projects. To achieve this goal, multiple independent variables (i.e., project characteristics, team selection, and team behavior) and dependent variables (i.e., performance measures) were collected for each project and recorded in the database. The independent and dependent variables studied are shown in Table 2.

Table 2. List of dependent and independent variables collected in the database

	Variables	Scale
Independent	Level of design complexity	1=Low to 5=High
	Level of construction complexity	1=Low to 5=High
	Time design-builder contracted for the project	Pre-design: Concept 0-15%; Schematic 15-30% Design: Development 30-60%; Construction document 60-90%; and Bidding full DC
	Procurement method	Open bid; Qualification; 1-Stage RFP; 2-Stage RFP; and Sole Source
	Selection of design-builder in terms of price, technical proposal, design concept, experience, interview performance	1=Most important to 6=Least important
	Percentage of design completion when GMP put in place	Percent
	Third party to verify price	Yes or No
	Owner and design-builder relationship	First time or Repeat
	Formal partnering agreement	Yes, No, I do not know
	Design-builder upper managerial support	1=Ineffective to 5=Effective
	Team's prior experience	1=Low to 5=High
	Quality of input during the pre-construction phase	1=Low to 5=High
	Formality of communication among team members	1=Informal to 5=Formal
	Timeliness of communication	1=Never on time to 5=Always on time
	Electronic files and information sharing used by project team	1=Primarily paper-based to 5=All electronic

	Risk identification and allocation	1=Poor to 5=Excellent
	Trust between project team in term of competency trust, organizational trust, and relational trust	1=Low to 5=High
Dependent	Overall project success	1=Low to 5=High
	Design satisfaction	1=Not satisfied to 5=Exceed expectations
	Construction satisfaction	1=Not Satisfied to 5=Exceed expectations
	GMP negotiation satisfaction	1=Not satisfied to 5=Exceed expectations
	Early contractor input satisfaction	1=Not satisfied to 5=Exceed expectations
	Risk management satisfaction	1=Not satisfied to 5=Exceed expectations
	Innovation satisfaction	1=Not satisfied to 5=Exceed expectations
	Severity of claims arising in the field	1=Low to 5=High
	Severity of claims in terms of time to solve	1=Low to 5=High
	Severity of claim in terms of cost impact	1=Low to 5=High
	Percentage of cost growth	Percent
	Percentage of schedule growth	Percent

The null hypothesis of the study was: there is no significant difference between the project performance metrics of PDB projects due to changes in independent variables. For each dependent variable, projects were classified into two groups (low and high). To determine whether there were significant differences in the PDB project performance measures due to any of the independent variables, the Mann-Whitney U test was used. The Mann-Whitney U test is a rank-based nonparametric test that can be used to determine the differences between two groups when data is ordinal. After testing the significance, the results should be reported based on whether the two distributions have similar shapes; the researcher should then compare the medians. If shapes are not similar, the researcher might compare mean ranks or distributions. In this research, the mean ranks were used to compare the two groups because the low number of cases made it harder to have similarly shaped distributions. The statistically significant ($P<0.05$) or partially significant ($P<0.1$) results obtained from the Mann-Whitney U test were reported and discussed.

Phase III: Determining the Importance of Influential Variables in Selecting a Delivery Method

The research team conducted a thorough literature search to identify a list of factors that impact the owner's decision in selecting a delivery method for a project. Factors identified from the literature search were presented in a questionnaire in the form of 25 statements such as "Owner's cash flow for the project is constrained" or "An above normal level of changes is anticipated in the execution of the project." To determine the relative importance of these factors in selecting different delivery methods, a follow-up online-questionnaire was distributed among 17 respondents who agreed to participate in the next phase of the study; all 17 completed the questionnaire. Respondents were asked to choose the most appropriate delivery methods (i.e., DBB, traditional DB, PDB, and CMAR) if any of the 25 statements applied to their project. Respondents could choose more than one delivery method for each statement. After collecting data, frequency of responses for each statement was calculated, and relative weight of each delivery method for each statement was determined.

CHAPTER FOUR: RESULTS

Phase I: Database

The majority of respondents reported that, although their projects had high levels of design (median=5) and construction (median=4) complexities, the projects were extremely successful (median=5): 13 projects were very successful; nine projects were successful; and only one project was neutral. This is an interesting finding because it demonstrates that PDB project success can be achieved even when the project has high design and construction complexity.

On average, guaranteed maximum price (GMP) was set when 67 percent of the design was complete (median=60%); GMP was set when design completion was 50 percent or less in only three projects. In 22 projects the design-builder included a contingency term; in 19 of these projects the contingency was part of the GMP. Based on the percentage of overall design completion, design build was contracted at the pre-design phase in ten projects; at the conceptual phase (0-15% completion) in seven projects; and at the schematic design phase (15-30% completion) in five projects.

Procurement methods included a two-stage RFP used for 15 projects; request for qualification used for six projects; and a one-stage RFP used for two projects. The respondents were also asked to rank factors that were considered in selecting the design-builder; the mean and mean ranks for these factors are shown in Table 3. The most important factor in selecting a design-builder was quality of the technical proposal (ranked most important for nine projects), and the least important factor was price (ranked least important for 13 projects).

Table 3. Factors ranked in terms of importance in the selection of design-builder (1=most important; 6=least important)

Selection factors	Median	Mean rank
Technical proposal	2	2.17
Experience	2	2.74
Similar project	3	3.61
Design concept	4	3.52
Interview performance	5	4.35
Price	6	4.83

Project performance measures

Respondents' ratings of their overall satisfaction with performance measures are shown in Table 4. On average, respondents were most satisfied with early contractor input and risk management (13 and 12, respectively), indicating that performance exceeded their expectations. As indicated in Table 5, PDB projects had a low level of disputes.

Team behavior and communication

Regarding team behavior and communication, owners and design-builders had previously worked together in only six of the 23 projects (repeated relationship); in 17 projects, owners and design-builders were working together for the first time. Formal partnering occurred in ten projects, and informal partnering took place in 13 projects.

Table 4. Overall satisfaction with performance measures (5=exceeds expectations; 1=not satisfied)

Satisfaction with	1	2	3	4	5	Median
Design process	0	0	3	14	6	4
Construction process	0	0	3	12	8	4
Negotiating the GMP	0	1	3	11	8	4
Early contractor input	0	1	1	8	13	5
Risk management	0	0	4	7	12	5
Innovation	0	0	2	13	8	4

Table 5. Performance measures related to disputes and claims (5=high; 1=low).

Metrics	1	2	3	4	5	Median
Frequency of claims which arose at the field level	11	8	4	0	0	2
Severity of claims which arose on the project (in terms of time to solve)	13	8	1	1	0	1
Severity of claims which arose on the project (in terms of cost impact)	11	9	3	0	0	2

Respondents' ratings of team behavior and communication indicators in each project are summarized in Table 6. Of the 23 projects, 17 (74%) had effective upper managerial support for the design-builder. Respondents also mentioned that quality input during the pre-construction phase was high, communication was timely most of the time, information sharing among team members was primarily electronic, and risk identification and allocation were close to excellent. Prior experience working as a team varied among projects and not all participants engaged in formal communication. While all respondents gave high ratings to competency, organizational, and relational trust among project stakeholders, relational trust rated highest among respondents.

Table 6. Team behavior and communication indicators

Variables	1	2	3	4	5	Median
Design-builder upper management support	0	0	2	4	17	5
Team's prior experience as a unit	2	0	7	6	8	4
Quality input during pre-construction phase	0	0	2	11	10	4
The formality of communication among team members	1	6	4	9	3	4
Timeliness of communication	0	0	5	11	7	4
Electronic file and information sharing	0	0	7	12	4	4
Risk identification and allocation	0	0	5	11	7	4
Competency trust	0	0	0	14	9	4
Organizational trust	0	0	6	7	10	4
Relational trust	0	0	4	7	12	5

Likert scale responses for each of these variables were: For design-builder upper management support (1=ineffective and 5=very effective); team prior experience as a unit, quality input during pre-construction phase (1=low and 5=high); the formality of communication among team members (1=informal and 5=formal); timeliness of communication (1=never on time and 5=always on time); electronic file and information sharing (1=primarily paper based and 5= all electronic); risk identification and allocation (1=poor and 5=excellent); competency trust, organizational trust, relational trust (1=low and 5=high).

Respondents also reported the original cost, original duration, and percentage of cost growth and schedule growth of their projects. The responses are summarized in Table 7.

Table 7. PDB project budget, duration, and cost, and schedule growth

Performance measures	Mean	Median	Minimum	Maximum
Project budget (million)	$254	$68	$14	$1,200
Project duration (months)	31.29	30.00	12	60
Cost growth (%)	0.05	0.01	0%	72%
Schedule growth (%)	0.05	0.00	0%	25%

Participants were asked, based on their experience, to compare PDB projects in terms of cost, schedule performance, and quality performance with traditional DB (lump-sum) projects. Responses to these questions are summarized in Table 8. Compared to traditional DB projects, 78% of PDB projects had lower cost growth; 74% had lower schedule delay; and 65% had higher quality performance.

Table 8. Comparison between performance of PDB and traditional DB projects.

Performance measures	Lower	No difference	Higher
Cost growth	18	2	3
Schedule delay	17	3	3
Quality	0	8	15

Phase II: Statistical Analysis

The results and salient findings of the statistical analysis on PDB performance database are presented here. The first independent variables that were studied were the impact of design and construction complexity of PDB projects on their performance. Projects were classified based on their levels of complexities into two groups of high and low. The medians of performance measures (i.e. dependent variables) were then compared by conducting the Mann-Whitney U test. The results are shown in Table 9, indicating that project complexities in design or construction had a significant effect on satisfaction with innovation. The overall satisfaction with innovation for projects with high design (U= 93.000, Z=1.884, P=0.104) or high construction complexities (U=96.000, Z=2.093, P=0.069) was higher than for projects with low design or low construction complexities.

Table 9. Impact of design and construction complexities on project performance

		Design complexity		Construction complexity	
Performance measures		Low	High	Low	High
Overall success	n	11	12	12	11

	MR	12	12	10.58	13.55
	p-value	1.000		0.316	
Cost growth	n	11	12	12	11
	MR	11.95	12.04	11.08	13
	p-value	0.449		0.525	
Schedule growth	n	11	12	12	11
	MR	13.18	10.92	13.21	10.68
	p-value	0.449		0.379	
Claims at Field	n	11	12	12	11
	MR	13.14	10.96	11.75	12.27
	p-value	0.449		0.880	
Claims time to solve	n	11	12	12	11
	MR	12.73	11.33	11.38	12.68
	p-value	0.651		0.651	
Claims cost impact	n	11	12	12	11
	MR	13.45	10.67	11.5	12.55
	p-value	0.347		0.740	
Satisfaction with design process	n	11	12	12	11
	MR	10.91	13	10.04	13.14
	p-value	0.478		0.151	
Satisfaction with construction process	n	11	12	12	11
	MR	12.45	11.58	11.38	12.68
	p-value	0.786		0.651	
Satisfaction with negotiating the GMP	n	11	12	12	11
	MR	13.05	11.04	13.38	10.5
	p-value	0.478		0.316	
Satisfaction with early contractor input	n	11	12	12	11
	MR	14.14	10.04	12.63	11.32
	p-value	0.151		0.651	
Satisfaction with risk management	n	11	12	12	11
	MR	12.18	11.83	11.83	12.18
	p-value	0.928		0.928	
Satisfaction with innovation	n	11	12	12	11
	MR	9.55	14.25	9.5	14.73
	p-value	0.104		0.069	

Since previous studies (e.g., Hasanzadeh et al. 2017) have shown that time of involvement can have a significant impact on project performance, in this project, information about the time the design-builders became involved in PDB projects was collected. Projects were grouped based on time of involvement: projects in which the design-builder was contracted in the pre-design phase versus projects in which the design-builder was contracted during the conceptual design phase and afterwards. A comparison of performance between these two groups indicated that early involvement of the design-builder resulted in higher performance, as shown in Table 10. Specifically, project overall success (U=37.000, Z=-1.991, P=0.088), satisfaction with construction process (U=20.000, Z=-3.091, P=0.004), satisfaction with design process (U=38.500, Z=-1.890, P=1.101), and satisfaction with early contractor input (*U*=25.500, *Z*=-2.776, *P*=0.012) were higher in projects for which the design-builder contracted in the conceptual or schematic design phase than in projects for which the design-builder contracted in the pre-design phase. The frequency of claims was also higher in projects for which the design-builder contracted in the pre-design phase than in projects for which the design-builder contracted in the conceptual or schematic design phase (*U*= 96.500, *Z*= 2.125, *P*= 0.049).

Projects also were compared based on procurement method (Table 10): projects procured using 1-stage RFP or qualification and projects procured using 2-Stage RFP. Satisfaction with construction process (*U*=20.000, *Z*=-2.860, *P*=0.008), GMP negotiation (*U*=28.500,*Z*= -2.208, *P*= 0.040), and risk management (*U*= 25.500, *Z*=-2.450, *P*=0.023) was higher for projects procured with 1-stage RFP or request for qualification than for projects procured with 2-stage RFP. Percentage of cost growth was higher for projects procured with 2-stage RFP than for projects procured with 1-stage RFP or request for qualification (*U*=96.500, *Z*=2.498, *P*=0.016).

Projects also were grouped based on the percentage of design that was completed at the time GMP was set: less than or equal to 60% vs. more than 60% (see Table 10). The severity of project claims in terms of cost impact (*U*=23.000, *Z*=-2.436, *P*=0.028) and time to resolve *(U*=28.000, *Z*=-2.332, *P*=0.043*)* was higher for projects in which GMP was set at the time the design was less than 60 percent developed than for projects in which GMP was set after 60 percent of the design was completed.

Table 10. Impact of time of involvement, procurement, and percentage of design completion when setting the GMP on project performance

Factors		Time of involvement		Procurement		Percent of design setting GMP	
Categories		Pre-design	Conceptual design & afterwards	1-stage RFP & Qualification	2-Stage RFP	More than 60%	Less than 60%
Overall success	n	13	10	8	15	9	13
	MR	9.85	14.8	15.63	10.07	11.11	11.77
	p-value	**0.088**		**0.065**		0.845	
Cost growth	n	13	10	8	15	9	13
	MR	12.73	11.05	7.44	14.43	11.50	11.50
	p-value	0.563		**0.016**		1.000	
Schedule growth	n	13	10	8	15	9	13
	MR	12.65	11.15	11.13	12.47	12.06	11.12
	p-value	0.605		0.681		0.744	
Claims at field	n	13	10	8	15	9	13
	MR	14.42	8.85	8.38	13.93	9.00	13.23

	p-value	**0.049**		**0.065**		0.144	
Claims time to solve	n	10	13	8	15	9	13
	MR	12.8	11.38	9.63	13.27	8.11	13.85
	p-value	0.648		0.238		**0.043**	
Claims cost impact	n	10	13	8	15	9	13
	MR	12.2	11.85	10.5	12.8	7.67	14.15
	p-value	0.927		0.466		**0.021**	
Design process	n	13	10	8	15	9	13
	MR	9.96	14.65	13.19	11.37	13.17	10.35
	p-value	**0.101**		0.548		0.324	
Construction process	n	13	10	8	15	9	13
	MR	8.54	16.5	17	9.33	11.39	11.39
	p-value	**0.004**		**0.008**		0.948	
Negotiating the GMP	n	13	10	8	15	9	13
	MR	10.42	14.05	15.94	9.9	11.33	11.62
	p-value	0.208		**0.04**		0.948	
Early contractor input	n	13	10	8	15	9	13
	MR	8.96	15.95	15.69	10.03	12.50	10.81
	p-value	**0.012**		**0.056**		0.556	
Risk management	n	13	10	8	15	9	13
	MR	10.38	14.1	16.31	9.7	13.33	10.23
	p-value	0.208		**0.023**		0.292	
Innovation	n	13	10	8	15	9	13
	MR	10.27	14.25	13.31	11.3	12.94	10.50
	p-value	0.166		0.506		0.393	

To further understand the role of selection factors in performance of PDB projects, respondents were asked to rank the importance of several factors in selecting a design-builder. To analyze data, projects were divided into groups based on the relative importance of these factors, and the mean rank of performance measures for each group was compared using the Mann-Whitney U test. The results of the analysis are shown in Table 11. For projects in which quality of technical proposal was considered an important factor in selecting the design-builder (top 3 or most important<3), percentage of schedule growth ranked higher than it did for projects in which the quality of the technical proposal was considered to be less important (less important>3), (U=24.000, Z=-2.640, P= 0.019). For projects in which the quality of the design concept was considered less important (less important >3), satisfaction with the construction process ranked higher than it did for projects in which the design concept was considered to be most important (most important <3), (U=33.500, Z=-2.215, P= 0.044). For projects in which experience was considered an important factor in selecting the design-builder (most important <3), satisfaction with early contractor input ranked higher than it did for projects in which experience was considered less important (less important >3), U=105.000, Z=2.720, P= 0.016.

Table 11. Impact of selection factors on project performance

		Importance of technical proposal		Importance of design concept		Importance of experience of DB	
Categories		Low	High	Low	High	Low	High
Overall success	n	15	8	12	11	11	12
	MR	11.87	12.25	13.33	10.55	12.55	11.5
	p-value	0.925		0.347		0.740	
Cost growth	n	15	8	12	11	11	12
	MR	13.87	8.5			12.23	11.79
	p-value	0.294		0.833		0.487	

Schedule growth	n	15	8	12	11	11	12
	MR	14.4	7.5			11.05	12.88
	p-value	**0.019**		0.235		0.525	
Claims at field	n	15	8	12	11	11	12
	MR	12.03	11.94	12.25	11.73	13.14	10.96
	p-value	0.975		0.880		0.449	
Claims time to solve	n	15	8	12	11	11	12
	MR	12.2	11.62	11.75	12.27	12.68	11.38
	p-value	0.875		0.880		0.651	
Claims cost impact	n	15	8	12	11	11	12
	MR	12.13	11.75	10.67	13.45	13.45	10.67
	p-value	0.925		0.347		0.347	
Design process	n	15	8	12	11	11	12
	MR	11.37	13.19	13.13	10.77	11.55	12.42
	p-value	0.548		0.413		0.786	
Construction process	n	15	8	12	11	11	12
	MR	12.33	11.38	14.71	9.05	9.27	14.5
	p-value	0.776		**0.044**		**0.069**	
Negotiating the GMP	n	15	8	12	11	11	12
	MR	11	13.88	12.63	11.32	10.5	13.38
	p-value	0.357		0.651		0.316	
Early contractor input	n	15	8	12	11	11	12
	MR	13.13	9.88	13.5	10.36	8.45	15.25
	p-value	0.294		0.288		**0.016**	
Risk management	n	15	8	12	11	11	12
	MR	11.97	12.06	12.29	11.68	11.32	12.62
	p-value	1.000		0.833		0.651	
Innovation	n	15	8	12	11	11	12
	MR	11.3	13.31	13.63	10.23	12.14	11.88
	p-value	0.506		0.235		0.928	

To study the impact of team behavior on performance of projects delivered using the PDB method, variables collected in the database included use of partnering, prior team experience as a unit, quality of input shared during the pre-construction phase of the project, electronic information shared between project's team members, and risk identification and allocation. The results of the analysis are shown in Table 12. Projects involving a formal partnering agreement showed a higher overall success rate than projects that did not use a formal partnering agreement (*U*=93.000, *Z*=1.991, *P*= 0.088). Projects whose teams had a higher degree of prior experience as a unit ranked higher than projects with low prior team experience in satisfaction with construction process (*U*=98.000, *Z*=2.442, *P*=0.028), early contractor input (*U*=96.000, *Z*=2.356, *P*= 0.039), innovation (*U*=94.500, *Z*=2.249, *P*= 0.046), overall success (*U*=89.000, *Z*=1.878, *P*=0.109), satisfaction with design process (*U*=93.500, *Z*=2.210, *P*=0.053), and satisfaction with risk identification and allocation (*U*=91.000, *Z*=1.941, *P*=0.083). Also, the frequency of claims that arose at the field level was higher for projects with low prior team experience than projects with high prior team experience (*U*=32.500, *Z*=-2.090, *P*=0.053).

PDB projects with a higher quality of input shared during the pre-construction phase resulted in better performance in these areas: overall project success (*U*= 93.000, *Z*=1.991, *P*=0.088) and overall satisfaction with the design process (*U*=110.000, *Z*=3.210, *P*=0.004), construction process (*U*=110.000, *Z*=3.091, *P*=0.004), early contractor input (*U*=104.500, *Z*=2.776, *P*=0.012), risk management (*U*=101.000, *Z*=2.456, *P*=0.026), and innovation (*U*=98.000, *Z*=2.320, *P*=0.042). The frequency of claims that arose at the field level was higher for projects with low-quality input shared during the pre-construction phase than for projects with high-quality input (*U*=33.500, *Z*=-2.125, *P*=0.049).

One surprising finding was related to the means of sharing information in PDB projects. Projects that used paper or no electronic information sharing had better performance than projects that primarily used electronic sharing information. Satisfaction with risk management was higher for projects that primarily used paper or no electronic information sharing than for projects that primarily used electronic sharing information (*U*=22.00, *Z*=-1.828, *P*=0.100). Severity of claims in terms of cost impact was higher for projects that primarily used electronic sharing information than for projects that primarily used paper or no electronic information sharing (*U*=64.500, *Z*=2.064, *P*=0.056). Projects with excellent risk identification and allocation scored higher in overall project success (*U*=91.000, *Z*=2.681, *P*=0.018), satisfaction with construction process (*U*=88.500, *Z*=2.405, *P*=0.027), and satisfaction with risk management (*U*=85.00, *Z*=2.132, *P*=0.055).

Table 12. Impact of team behavior (formal partner agreement, DB upper management support, team prior experience) on project performance

Factors		Formal partner agreement		Design-builder upper management support		Team's prior experience as a unit	
Categories		Yes	No	High	Low	High	Low
Overall success	n	10	13	17	6	14	9
	MR	14.8	9.85	12.26	11.25	13.86	9.11
	p-value	**0.088**		0.201		**0.109**	
Cost growth	n	10	13	17	6	14	9
	MR	10.2	13.38	12.5	10.58	12.54	11.17
	p-value	0.284		0.562		0.643	
Schedule growth	n	10	13	17	6	14	9
	MR	11.1	12.6	12.06	11.83	11.32	13.06
	p-value	0.605		1		0.557	
Claims at field level	n	10	13	17	6	14	9
	MR	11.35	12.5	10.62	15.92	9.82	15.39

	p-value	0.693		**0.101**		**0.053**	
Claims time to solve	n	10	13	17	6	14	9
	MR	10.7	13	11.03	14.75	11.14	13.33
	p-value	0.446		0.256		0.477	
Claims cost impact	n	10	13	17	6	14	9
	MR	11.6	12.31	11.41	13.67	11.14	13.33
	p-value	0.832		0.516		0.477	
Design process	n	10	13	17	6	14	9
	MR	13.65	10.73	12.53	10.5	14.18	8.61
	p-value	0.313		0.562		**0.053**	
Construction process	n	10	13	17	6	14	9
	MR	14.5	10.08	14.21	5.75	14.5	8.11
	p-value	0.131		**0.006**		**0.028**	
Negotiating the GMP	n	10	13	17	6	14	9
	MR	13.35	10.96	13.09	8.92	12.39	11.39
	p-value	0.41		0.201		0.734	
Early contractor input	n	10	13	17	6	14	9
	MR	13.3	11	14.21	5.75	14.36	8.33
	p-value	0.446		**0.006**		**0.039**	
Risk management	n	10	13	17	6	14	9
	MR	14.1	10.3	13.18	8.67	14	8.89
	p-value	0.208		0.177		**0.083**	
Innovation	n	10	13	17	6	14	9
	MR	11.4	12.46	12.26	11.25	14.25	8.5
	p-value	0.738		0.759		**0.046**	

Factors		Quality input during pre-construction phase		The formality of communication among team members		Timeliness of communication		Electronic file and information sharing		Risk identification and allocation	
Categories		High	Low	High	Low	High	Low	High	Low	High	Low
Overall success	n	10	13	12	11	7	16	12	7	7	15
	MR	14.8	9.85	13.33	10.55	12.29	11.88	9.63	10.64	17	9.81
	p-value	**0.088**		0.347		0.922		0.711		**0.018**	
Cost growth	n	10	13	12	11	7	16	12	7	7	15
	MR	11.55	12.35	13.46	10.41	13.57	11.31	10.71	8.79	13	11.56
	p-value	0.784		0.288		0.492		0.482		0.671	
Schedule growth	n	10	13	12	11	7	16	12	7	7	15
	MR	10.55	13.12	11.67	12.36	10.79	12.53	10.88	8.5	8.71	13.44
	p-value	0.376		0.833		0.579		0.384		0.135	
Claims at field level	n	10	13	12	11	7	16	12	7	7	15
	MR	8.85	14.42	11.46	12.59	10.93	12.47	10.5	9.14	12.29	11.88
	p-value	**0.049**		0.695		0.624		0.65		0.922	
Claims time to solve	n	10	13	12	11	7	16	12	7	7	15
	MR	11.75	12.19	12.63	11.32	12.29	11.88	10.88	8.5	12.14	11.94
	p-value	0.879		0.651		0.922		0.384		1	
Claims cost impact	n	10	13	12	11	7	16	12	7	7	15
	MR	11.2	12.62	12.33	11.64	12	12	11.88	6.79	12.57	11.75
	p-value	0.649		0.833		1		**0.056**		0.82	
Design process	n	10	13	12	11	7	16	12	7	7	16
	MR	16.5	8.54	12.42	11.55	12.14	11.94	8.96	11.79	13.57	11.31
	p-value	**0.004**		0.786		1		0.299		0.492	
Construction process	n	10	13	12	11	7	16	12	7	7	16
	MR	16.5	8.54	13.04	10.86	15.21	10.59	9.17	11.43	16.64	9.97
	p-value	**0.004**		0.449		0.135		0.432		**0.027**	
Negotiating the GMP	n	10	13	12	11	7	16	12	7	7	16
	MR	14.05	10.42	13.21	10.68	12.71	11.69	10.38	9.36	14.14	11.06

	p-value	0.208		0.379		0.769		0.711		0.341	
Early contractor input	n	10	13	12	11	7	16	12	7	7	16
	MR	15.95	8.96	12.17	11.82	14	11.13	8.79	12.07	14	11.13
	p-value	**0.012**		0.928		0.376		0.227		0.376	
Risk management	n	10	13	12	11	7	16	12	7	7	16
	MR	15.6	9.23	10.58	13.55	12.64	11.72	8.33	2.86	16.14	10.19
	p-value	**0.026**		0.316		0.769		0.1		0.055	
Innovation	n	10	13	12	11	7	11	12	7	7	16
	MR	15.3	9.46	13.38	10.5	15	10.69	8.75	12.14	15.43	10.5
	p-value	**0.042**		0.316		0.175		0.227		0.118	

Table 13. Impact of team behavior (quality input, formality of communication, timeliness of communications, electronic sharing information, risk identification) on project performance

To better understand the impact of trust on project performance, projects were characterized as high (rated as 5) and low (rated less than 5) according to competency, organizational, and relational trust. The results of the analysis are shown in Table 14, indicating that higher trust resulted in better performance for a majority of factors:

- *Competency trust*: Overall project success (U=97.000, Z=2.455, P=0.033), satisfaction with construction process (U=100.500, Z=2.616, P=0.016), satisfaction with design process (U=89.500, Z=1.920, P=0.096), and satisfaction with risk management (U=93.500, Z=2.114, P=0.053) were higher for projects with high competency trust than for projects with low competency trust. Frequency of claims

(*U*=18.500, *Z* =-3.050, *P*= 0.003) and severity of claims in terms of both time to solve (*U*=28.500, *Z*=-2.463, *P*=0.028) and cost impact (*U*=25.00, Z=-2.627, *P*=0.016) were higher for projects with low competency trust than for projects with high competency trust.

- *Organizational trust*: Satisfaction with construction process (U=110.000, Z=3.091, P=0.004), innovation (U=98.000, Z=2.320, P=0.042), negotiating the GMP (U=92.500, Z=1.852, P=0.088), early contractor input (U=94.000, Z= 2.038, P= 0.077), and overall success satisfaction (U=93.000 , Z= 3.091, P= 0.088) were higher for projects with high organizational trust than for projects with low organizational trust, while frequency of claims at field level was higher for projects with low organizational trust than for projects with a high level of organizational trust (*U*=14.500, *Z*=-3.407, *P*=0.001).
- *Relational trust*: Satisfaction with construction process (U=106.000, Z=2.727, P=0.013), early contractor input (U=94.500, Z=1.988, P=0.079), innovation (U=96.000, Z=2.093, P=0.069), and risk management (U=113.000, Z=3.183, P=0.003) were higher for projects with high relational trust than for projects with low relational trust, while frequency of claims (U=32.000, Z=-2.277, P=0.037) and severity of claims in term of time to solve (*U*= 37.500, *Z*=-1.988, *P*=0.079) were higher for projects with low relational trust than for projects with high relational trust.

Table 14. Impact of trust on project performance

		Competency		Organizational		Relational	
		High	Low	High	Low	High	Low
Overall success	n	9	14	10	13	12	11
	MR	15.78	9.57	14.8	9.85	14.25	9.55
	p-value	**0.033**		**0.088**		**0.104**	
Cost growth	n	9	14	10	13	12	11
	MR	12.89	11.43	11.55	12.35	10.5	13.64
	p-value	0.643		0.784		0.288	
Schedule growth	n	9	14	10	13	12	11
	MR	12.33	11.79	11.5	12.38	10.33	13.82
	p-value	0.877		0.784		0.235	
Claims at field level	n	9	14	10	13	12	11
	MR	7.06	15.18	6.95	15.88	9.17	15.09
	p-value	**0.003**		**0.001**		**0.037**	
Claims time to solve	n	9	14	10	13	12	11
	MR	8.17	14.46	10.15	13.42	9.63	14.59
	p-value	**0.028**		0.257		**0.079**	
Claims cost impact	n	9	14	10	13	12	11
	MR	7.78	14.71	9.6	13.85	9.83	14.36
	p-value	**0.016**		0.148		0.118	
Design process	n	9	14	10	13	12	11
	MR	14.94	10.11	13.65	10.73	13.96	9.86
	p-value	**0.096**		0.313		0.151	
Construction process	n	9	14	10	13	12	11
	MR	16.17	9.32	16.5	8.54	15.33	8.36
	p-value	**0.016**		**0.004**		**0.013**	
Negotiating the GMP	n	9	14	10	13	12	11
	MR	13.44	11.07	14.75	9.88	14.17	9.64
	p-value	0.439		**0.088**		0.118	
Early contractor input	n	9	14	10	13	12	11
	MR	14.67	10.29	14.9	9.77	14.38	9.41
	p-value	0.141		**0.077**		**0.079**	
Risk management	n	9	14	10	13	12	11
	MR	15.39	9.82	14.1	10.38	15.92	7.73
	p-value	**0.053**		0.208		**0.003**	
Innovation	n	9	14	10	13	12	11
	MR	14.83	10.18	15.3	9.46	14.5	9.27
	p-value	**0.109**		**0.042**		**0.069**	

No statistically significant results were found for price, interview performance, using third party to verify price, owner/contractor relationship, formality of communication between project team, or timeliness of communication in relation to PDB project performance measures.

Phase III: Selection Factors

Responses to the questionnaire regarding influential variables in selecting a delivery method are shown in Table 15. Participants selected the PDB as the most suitable project delivery method for 16 out of 25 factors. Respondents believed that when the following factors exist in a project, PDB would be the more suitable delivery system: owner cash flow for the project is constrained; project design/engineering or construction is complex, innovative or non-standard; project schedule provides limited time to develop the procurement and enter into contract; early procurement of long-lead equipment and/or materials is critical to project success; an above normal level of changes is anticipated in the execution of the project; and project scope is flexible. On the other hand, when a below normal level of changes is anticipated in the execution of the project, or local conditions at project site are favorable to project execution, or project features are well defined at the award of the design and/or construction contract, PDB would not be the best method to deliver a project.

Table 15. PDB Selection factors

		DBB		DB		PDB		CMAR		
	Selection Factors	n	%	n	%	n	%	n	%	Total
1	Completion within original budget is critical to project success	1	4%	8	33%	9	38%	6	25%	24
2	Minimal cost is critical to project success	3	20%	6	40%	4	27%	2	13%	15
3	Owner cash flow for the project is constrained	0	0%	1	7%	9	60%	5	33%	15
4	Owner critically requires early (and reliable) cost figures to facilitate financial planning and business decisions	2	11%	2	11%	9	47%	6	32%	19
5	Owner assumes minimal financial risk on the project	1	6%	4	25%	6	38%	5	31%	16
6	Completion within schedule is highly critical to project success	1	5%	6	29%	9	43%	5	24%	21
7	Early completion is critical to project success	1	6%	2	12%	8	47%	6	35%	17
8	Early procurement of long-lead equipment and/or materials is critical to project success	1	5%	1	5%	10	50%	8	40%	20
9	An above normal level of changes is anticipated in the execution of the project	3	19%	0	0%	8	50%	5	31%	16
10	A below normal level of changes is	5	31%	5	31%	3	19%	3	19%	16

	anticipated in the execution of the project									
11	Confidentiality of business/engineering details of the project is critical to project success	1	6%	4	25%	7	44%	4	25%	16
12	Local conditions at project site are favorable to project execution	6	24%	9	36%	5	20%	5	20%	25
13	Owner desires a high degree of control/ influence over project execution	4	20%	3	15%	8	40%	5	25%	20
14	Owner desires a substantial use of its own resources in the execution of the project	4	20%	2	10%	7	35%	7	35%	20
15	Project features are well defined at the award of the design and/or construction contract	7	33%	8	38%	3	14%	3	14%	21
16	Owner prefers minimal number of parties to be accountable for project performance	2	11%	8	44%	7	39%	1	6%	18
17	Project design/ engineering or construction is complex, innovative or non-standard	1	6%	2	11%	10	56%	5	28%	18
18	Capital availability uncertain	2	11%	1	5%	9	47%	7	37%	19
19	Staff desire to participate in scope advancement	3	13%	2	9%	10	43%	8	35%	23

20	Project schedule provides limited time to develop the procurement and enter into contract	3	17%	1	6%	10	56%	4	22%	18
21	Permitting requirements likely impact the scope of the project	4	19%	2	10%	9	43%	6	29%	21
22	Land acquisition likely impacts the alignment or orientation of project	3	15%	3	15%	8	40%	6	30%	20
23	Schedule dictates initiation of key project activities before all capital funding available	3	14%	1	5%	9	43%	8	38%	21
24	Project scope is flexible	2	10%	3	15%	10	50%	5	25%	20
25	Owner wants to maximize control of the project	5	31%	2	13%	6	38%	3	19%	16
	Total of choices	68		86		193		128		475
	Median	3		2		8		5		19
	Average	2.7		3		7.7		5.1		19

CHAPTER FIVE: DESCRIPTIVE ANALYSIS

Based on respondents' 32 years of personal experience and judgment, it can be concluded that PDB performs better in project delivery than traditional DB in terms of cost growth, schedule growth, and quality. An interesting observation regarding team behavior and communication implies that owners and design-builders who have not worked with each other previously can still be successful in PDB projects. Because the design-builder in PDB is selected based on qualifications and past performance, PDB provides an opportunity to engage the design-builder early during the design process to work collaboratively with the owner to develop the project design with progressive estimates of project costs and schedule to meet the owner's goals until the design is defined. At this stage of design development, the owner has a high degree of cost and schedule certainty, increasing the likelihood of project success (DBIA, 2017; Gransberg and Molenaar 2019; Michael C. Loulakis 2013).

Statistical Analysis Discussion

Project complexity

It was found that as design and construction complexities increase, the overall satisfaction with the innovation process increases. Innovation in construction requires a strategy with a high planning level and high team collaboration to improve project performance (Xue et al. 2018). The close contact in PDB between owner and design-builder in designing the facility, incorporating ideas, and finding solutions for project challenges (cost, schedule, quality) are advantages of the PDB project delivery method (Gransberg and Molenaar 2019).

Time of involvement

One unexpected finding of the study was that involving the design-builder at the earliest time (i.e., pre-design phase) does not necessarily lead to higher performance. For example, while contracting with the DB in the pre-design phase would result in higher overall success, satisfaction with design process, and lower claims at field, it results in lower satisfaction with the construction process and early contractor input. The reason for that is in the pre-design phase project scope did not develop yet, and the owner will not be satisfied with design-builder input. Also, in the pre-design phase, there are no drawings or much detail about the project – it is only the owner's dream and thoughts. While Involving the design-builder during the conceptual planning phase enhances constructability because the project scope is developed, and the owner will be satisfied with design-builder input. This input will influence the development of the project plan by taking into account site layout preparation, weather considerations that affect the project schedule, design quality, design preparation, and selection of construction methods and resources to complete construction on time (Tatum 1987). The case study research of Tatum (1987) showed the importance of constructability during the conceptual planning phase in decreasing construction scope, reducing construction difficulty, recognizing local practice, improving material supply, and reaching project success.

Procurement method

Projects procured using 2-stage RFP had poor performance in comparison with other procurement methods. These projects had lower overall success and lower satisfaction with construction process, negotiating the GMP, early contractor input, and risk management, as well as higher claims in the field. According to Loulakis (2013), "While the two-phase process can work quite well, it has some notable drawbacks. First, the RFP usually includes a mandatory baseline design that is approximately 35 percent complete, with requirements being stated in terms of specific design approaches that the design-build offers must follow. This approach not only limits innovation, but it creates a potential liability to the owner if there are problems in what it has furnished in the RFP. Second, the process of creating the RFP and evaluating the proposals can be costly and time-consuming" (Michael C. Loulakis 2013, June 4; Gransberg and Molenaar 2019 p. 3). Selecting the design-builder based on qualifications helps avoid the 2-stage issue and opens the door to design-builder services early in the project, resulting in more collaborative team work (Gransberg and Molenaar 2019).

Selection factors for design-builder

Considering the technical proposal as the most crucial factor in selecting the design-builder showed a statistically significant relationship with schedule growth. This result supports previous research (Paek et al. 1992) about selecting the design-builder's proposal based on high technical degree and low cost. It is very important to select the design-builder's proposal based on the high technical details of the listed project requirements and the proposal's ability to address all approaches that solve project issues. This is in contrast to the research of Chan et al. (2001), who used multivariate analysis and found the second important factor that impacts the design-build project is the contractor's technical capability and understanding of the design process.

Another finding was that satisfaction with the construction process can be achieved without considering the design concept of the design-builder as the most important factor in selecting the design-builder. This can be attributed to the fact that in PDB projects, the design will be developed in close collaboration between the DB and owner; therefore, assigning large weight to the design concept would not necessarily lead to higher performance.

Previous experience with the design-builder had statistically significant impact on overall satisfaction with early contractor input. This can be explained by the fact that the design-builder already knows and understands this type of delivery method and understands the owner's needs from previous experience. Other studies also have emphasized the importance of contractor experience during the evaluation process of design-build project delivery, as it affects the project performance in terms of cost and time (Chan et al. 2001).

Percent of design setting GMP

The impact on project performance of the time at which GMP is set is significant in regard to severity of claims in terms of cost and time to solve the claim. The reason is related to the accuracy of cost estimation when the GMP is set. When GMP is set when design is less complete, accuracy is lower and there is a risk of having more unknowns. PDB offers progressive estimation of project cost and schedule from the initial design to negotiation of the construction price. During this process, the owner is warned when the cost exceeds the project budget and can make changes to control cost and schedule and minimize risk (Gransberg and Molenaar 2019). After 60% of design completion, the contractor has most of the information needed to understand the design complexities and provide a much more accurate cost estimation. In addition, as the percentage of design completion increases, the contractor would be in a better position to reduce uncertainties associated with typical design-build projects and subsequently reduce the number of contingencies to cover potential risks. This finding is in consistence with Lin and Liu's (2004) finding that completing larger portions of the design before fixing project costs will result in higher intensity and lower cost or schedule growth (Paek et al. 1992).

Team behavior

Developing a formal partnering agreement will lead to higher overall success, because partnering is a win-win approach to an effective project management process that can achieve a high degree of success through open communication and a collaborative culture between project parties (Chan et al. 2004; Wong and Cheung 2005). Partnering refers to the contractual commitment between members of the project team to create a trusted environment and improve collaboration. This will help the project team work together, not against each other, to solve problems and decrease disputes (Chan et al. 2004).

Higher team prior experience results in higher overall success, satisfaction with construction and design processes, early contractor input, innovation, and risk management, and lower frequency of claims that arise at the field level. In PDB, the design-builder and owner need to collaborate closely to design the project and come up with a reasonable cost; therefore, prior team experience will lead to better communication, greater trust, and more efficient collaboration with each other during the design and construction phases of the project; all parties will benefit from each party's experience and skills to solve project issues and reduce risks. Working relationships and prior experience influence the project environment in terms of team interaction and communication (Hasanzadeh et al. 2018b).

The quality of input shared during the pre-construction phase of the project was also found to have significant impact on several performance measures: as the quality of input increases, the overall project success and satisfaction with design and construction processes, early contractor input, risk management, and innovation increase, and frequency of claims that arise at the field level decreases. Higher quality of information in the pre-construction phase will help with better constructability, leading to better performance. Constructability is a success factor that affects project schedule performance, quality performance, and overall performance (Kog and Loh 2012).

A surprising and unexpected finding was related to the means of sharing information in PDB projects. Projects that used paper or no electronic information sharing had better performance than projects that primarily used electronic sharing information. The projects that primarily used paper for sharing information had high satisfaction regarding risk management and low claims in terms of cost impact. The cost of printing, mailing paper documents, and distributing them to the project team is not as expensive compared to purchasing online software for information sharing. Electronic papers are more powerful in transferring and updating project information, but it is difficult for all project parties to locate new updated electronic documents or information. For example, an old-school owner and project manager might waste time searching for project information and becoming familiar with electronic files. Also, the contractor and subcontractor might be unable to find updated decisions, leading to many change orders and project delays.

Projects with excellent risk identification and allocation had higher overall project success and satisfaction with construction process and risk management than projects with poor risk identification and allocation. PDB provides an opportunity for owners and design-builders to discuss the risk profile early, based on real-time information rather than assumptions (Gransberg and Molenaar 2019). Therefore, as long as risk identification is high, risk sharing will be reduced. Thanh Luu et al. (2003) recommended paying more attention to risk allocation factors because it enhances the procurement process by managing, sharing, or transferring the risk to another organization – for example, the design-builder. Findings of this study corroborate the importance of implementing risk identification and allocation in enhancing project success.

As far as trust is concerned, higher levels of trust (i.e., competency, organizational, and relational) lead to better performance in terms of higher overall project success, higher satisfaction with construction and design processes, risk management, innovation, negotiating the GMP, early contractor input, and lower frequency and severity of claims. Trust demonstrates the ability to commit to project goals and deal with different opinions and attitudes (Hasanzadeh et al. 2016). Project participants are willing to share important information if they cooperate and trust each other. Therefore, mutual trust, cooperation, and communication among project participants contribute to project success. Trust in the highly collaborative environment of the PDB method could facilitate information sharing, enhance risk allocation, and create good relationships between team members (Hasanzadeh et al. 2016; Wang and Yin 2013). Higher organizational trust creates higher satisfaction with negotiating the GMP because it leads to clarity, fairness, and a trustful environment that enhances the process of negotiating the GMP within the contract team. Chan et al. (2001) conducted a study to identify the critical factors that contribute to design-build projects and found the highest factors affecting project outcome are team commitment, trust, and a good work relationship. Therefore, trust is an important factor that the project team should consider and improve (Hasanzadeh et al. 2018b).

Selection factors

The most critical factors affecting the owner's decision to select the PDB project delivery method were: flexible project scope, staff's desire to participate in scope advancement, uncertain capital availability, limited time for procurement process, the necessity for early procurement of long-lead equipment and materials, and higher complexity of design and construction. One of the major limitations of the DB delivery method is that after awarding the contract, the owner has minimal interference with the design and project scope to avoid change orders that may lead to cost and schedule growth (Beard et al. 2001). However, in the PDB delivery method, since the owner will be involved in scope advancement and design development, there will be more flexibility for owners to influence project scope while considering budget limitations. This flexibility in defining project scope is critical when permitting requirements are likely to impact the scope of the project. In addition, since the construction and procurement of long-lead equipment and materials can be started before the design is 100 percent complete, the project duration would be shorter. These characteristics make PDB an attractive delivery method for projects in which the schedule dictates initiation of key project activities before all capital funding is available.

CHAPTER SIX: CONCLUSIONS

This thesis empirically investigated the performance and characteristics of projects delivered using the progressive design build method by establishing a database of completed PDB projects and conducting multiple statistical analyses. The significant results of the statistical analyses provided best practices for owners to increase their chances in achieving success in PDB projects. For example, to reduce severity of disputes in a project, it is better to set the GMP when the design has developed more than 60 percent. In addition, this study identified and prioritized influential variables in selecting PDB as a delivery method. This study has contributions to both academia and practice. As far as academia is concerned, this study is the first attempt to establish a performance database of PDB projects. Practitioners also can benefit from the results as the project has identified best practices for maximizing success in PDB projects, as well as guidelines for using PDB as a delivery method based on owner and project characteristics.

There are some limitations that need to be addressed in future studies. First, the sample size of the study was small; future studies should be conducted to further expand this database. Nonetheless, considering the small population of PDB projects, the sample size of the database is acceptable for preliminary study. Second, the collected projects were mainly from successful PDB projects; it would be better to expand the database and include unsuccessful PDB projects. Third, since some of the questions were qualitative and based on judgment of respondents, there is a possibility that respondents were biased. To overcome this challenge, it is suggested that performance data be collected from projects that use other delivery methods and conduct a comparative analysis. Future research can also develop a framework based on multi criteria decision making techniques to facilitate section of delivery methods based on project characteristics.

APPENDEX / QUESTIONNAIRE

THE PERFORMANCE OF PROGRESSIVE DB DELIVERY PROJECTS

Definitions

Progressive design build: It is a variation of design-build delivery method in which, the owner hires the design-builder at the early stage of the project even before developing the project design, moving forward to procure the project with a "Progressive" process of design improvement and construction estimation.

If you have read this form and all of your questions have been answered, please click below to indicate whether or not you consent to participate in this study.

O Yes O No

SECTION 1: **PERSONAL INFORMATION**

1. US state in which you are employed:

2. You are employed by what type of organization?
   □ State Department of Transportation
   □ Other public transportation agency; Name of Agency:
   □ Water/Wastewater:
   □ Other; Please describe:

3. What group/section do you work in?
   □ Design group/section
   □ Construction group/section
   □ Operations group/section
   □ Maintenance group/section
   □ Alternative project delivery group/ section
   □ Materials group/section
   □ Contracts/procurement group/section
   □ Other, please specify: ________________

4. Years of experience in construction industry:

SECTION 2: PROJECT GENERAL INFORMATION

5. Relative to your experience with similar project types, rate the following for this project (*with 1=Low to 5 =High*):

a) Level of design complexity:

low	1 O	2 O	3 O	4 O	5 O	high

b) Level of construction complexity

low	1 O	2 O	3 O	4 O	5 O	high

c) Overall success of this project

low	1 O	2 O	3 O	4 O	5 O	high

6. Please select when design-builder contracted for the project (timing as based on percent of overall design completion):

O Pre-Design
O Concept (0-15%)
O Schematic design (15-30%)
O Design development (30-60%)
O Construction document (60-90%)
O Bidding (Full CD)

SECTION 3: TEAM PROCUREMENT & CONTRACTS

7. Please select how proposals were solicited from design-builder (*select all that apply*)

O Open Bid
O Qualification
O 1-Stage RFP
O 2-Stage RFP
O Sole Source

8. Please rank the following factors in terms of importance in the selection of design-builder *from 1 to 6, with 1 = most important to 6= least important* (*type the no. in the table*)

____ Price
____ Technical proposal
____ Design concept
____ Similar Project
____ Experience
____ Interview Performance

9. What was the percentage of design completion when Guaranteed Maximum Price (GMP) was put in place?

____

10. Did the Design-Builder has a contingency term on this project?
O Yes

O No

11. Was contingency part of GMP or outside of GMP?
    O Part of GMP
    O Outside of GMP

12. Did you use third party to verify price?
    O Yes
    O No

13. Rate your overall satisfaction with the following (with 1=Not satisfied to 5=Exceed expectations):

a) Design process

Not satisfied	1 O	2 O	3 O	4 O	5 O	Exceed expectations

b) Construction process

Not satisfied	1 O	2 O	3 O	4 O	5 O	Exceed expectations

C) Negotiation the Guaranteed Maximum Price (GMP)

Not satisfied	1 O	2 O	3 O	4 O	5 O	Exceed expectations

D) Early contractor input

Not satisfied	1 O	2 O	3 O	4 O	5 O	Exceed expectations

E) Risk management

Not satisfied	1 O	2 O	3 O	4 O	5 O	Exceed expectations

F) Innovation

Not satisfied	1 O	2 O	3 O	4 O	5 O	Exceed expectations

SECTION 4: CHANGE ORDER/DISPUTES

14. Based on your experience, how would you rate the following (with 1= low to 5=High):

a) Frequency of claims which arose at the field level

low	1 O	2 O	3 O	4 O	5 O	high

b) Severity of claims which arose on project (*in terms of TIME to resolve*)

low	1 O	2 O	3 O	4 O	5 O	high

c) Severity of claims which arose on project (*in terms of COST impact*)

low	1	2	3	4	5	high

	O	O	O	O	O	

SECTION 5: TEAM BEHAVIOR & COMMUNICATION

15. Indicate the owner's relationship type with design-builder:

O First time O Repeat

16. Did the project team use a formal partnering agreement?

    O Yes O No

    O I do not know

17. Please rate the following from 1 to 5:

a. Design-Builder's upper managerial support and responses

Ineffective	1 O	2 O	3 O	4 O	5 O	V. effective

b. Quality of the input shared during pre-construction phase of project

Low	1 O	2 O	3 O	4 O	5 O	High

c. Team's prior experience as a unit

low	1 O	2 O	3 O	4 O	5 O	high

d. Formality of communication among team members

Informal	1 O	2 O	3 O	4 O	5 O	Formal

e. Timeliness of communication

Never on time	1 O	2 O	3 O	4 O	5 O	Always on time

f. Electronic file & information sharing used by project team

Primarily paper-based	1 O	2 O	3 O	4 O	5 O	All electronic

g. Risks identification and allocation

Poor	1 O	2 O	3 O	4 O	5 O	Excellent

18. Please evaluate trust between your organization and the contractor considering the definitions below:
    - *Competency trust*: This trust is based on the confidence gained from knowledge of an individual or an organization's cognitive abilities. The competence and the integrity of an individual or an organization are based on the knowledge of their past performance, reputation, organizational role, and financial status.
    - *Organizational trust*: This is trust that is developed through organizational policies and addresses formal and procedural arrangements.

- *Relational trust*: Trust based on emotions that bonds people together thereby improving their performance and morale in a working relationship. These are trusts that enhance information exchange and team spirit, decrease defensiveness, unhealthy competitiveness, and eliminate frictions.

a) Competency trust

low	1 O	2 O	3 O	4 O	5 O	high

b) Organizational trust

low	1 O	2 O	3 O	4 O	5 O	high

c) Relational trust

low	1 O	2 O	3 O	4 O	5 O	high

SECTION 6: COST AND SCHEDULE

19. What was the original contract price?

____

20. What was the original duration of the project?

____

21. What was the percentage of cost growth?

____

22. What was the percentage of schedule growth?

____

23. Based on your experience, how do you compare cost performance of projects delivered using progressive design build with projects delivered using traditional design build (lump sum)?
    - O Less cost growth
    - O No difference
    - O Higher cost growth

24. Based on your experience, how do you compare schedule performance of projects delivered using progressive design build with projects delivered using traditional design build (lump sum)?
    - O Less schedule delay
    - O No difference
    - O Higher schedule delay

25. Based on your experience, how do you compare quality performance of projects delivered using progressive design build with projects delivered using traditional design build (lump sum)?

O Lower quality
O No difference
O Higher quality

Open ended questions:

Based on your experience in this project, please answer the following questions.

- What are the most important reasons to use Progressive Design-Build as an alternative delivery method?

- What are the most important reasons to not use Progressive Design-Build as an alternative delivery method?

- Under which circumstances do you recommend using Progressive Design-Build method to deliver a project?

- List any lessons you learned on this project:

26. Would you be willing to be contacted for the follow-up survey or interview to discuss additional information regarding the projects you provided:
    O Yes
    O No,

27. Please provide contact information:
    a. Contact name:
    b. Phone number:
    c. Email address

Follow up survey

If any of these statements applies to your project, which delivery methods would you select? (DBB, DB, PDB, CMR, cannot be determined)

1. Completion within original budget is critical to project success"
2. Minimal cost is critical to project success
3. Owner cash flow for the project is constrained
4. Owner critically requires early (and reliable) cost figures, to facilitate financial planning and business decisions
5. Owner assumes minimal financial risk on the Project
6. Completion within schedule is highly critical to project success
7. Early completion is critical to project success
8. Early procurement of long lead equipment and/or materials is critical to project success
9. An above normal level of changes is anticipated in the execution of the project
10. A below normal level of changes is anticipated in the execution of the project
11. Confidentiality of business/engineering details of the project is critical to project success
12. Local conditions at project site are favorable to project execution
13. Owner desires a high degree of control/influence over project execution
14. Owner desires a substantial use of its own resources in the execution of the project
15. Project features are well defined at the award of the design and/or construction contract
16. Owner prefers minimal number of parties to be accountable for project performance
17. Project design/engineering or construction is complex, innovative or non-standard
18. Capital availability uncertain.
19. Staff desire to participate in scope advancement.
20. Project schedule have limited time to develop the procurement and enter into contract.
21. Permitting requirements likely impacts the scope of the project.
22. Land acquisition likely impacts the alignment or orientation of project.
23. Schedule dictates initiation of key project activities before all capital funding available.
24. Project scope is flexible.
25. Owner wants to maximize control of the project

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