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Evaluation of Alternative Project Delivery Methods in Water and Wastewater Projects

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EVALUATION OF ALTERNATIVE PROJECT DELIVERY METHODS IN WATER AND WASTEWATER PROJECTS

By

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ABSTRACT

Evaluation of Alternative Project Delivery Methods in Water and Wastewater Projects

By

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The United States (U.S.) is facing significant challenges in addressing aging water infrastructure. Most of the drinking water infrastructure is reaching the end of their useful lives. The American Water Works Association (AWWA) estimated that it will cost about $1 trillion to repair or replace drinking water pipes. Over the next 20 years, it will cost about $298 billion to fix or expand pipes of the nation's wastewater and storm-water systems (AWWA, 2012). Owners, engineers, and contractors are using Alternative Project Delivery (APD) methods – e.g., Design-Build Construction Management-at-Risk Construction Management/General Contractor– to build water and wastewater projects in order to save time, cost, and improve the quality of the projects.

The purpose of the research was to find the owners' satisfaction levels regarding various benefits related to APD methods as well as different obstacles in using these methods in water and wastewater projects. In addition to this, it was to determine the

different satisfaction level of APD methods experienced by different levels of respondents as well as by type of project delivery method experience. A survey questionnaire was prepared and emailed to 455 utility owners to determine their assessments about these project delivery methods.

The results showed the majority of respondents were satisfied with various benefits provided by the APD methods. They also showed that Project Staff was significantly more satisfied with APD methods than Utility Manager. Design-Build users were significantly more satisfied with the quality of completed project than Construction Management-at-Risk users. In addition, Statistical analysis of the responses revealed important insight to interested parties of the water industry.

ACKNOWLEDGEMENTS

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I would like to acknowledge the support from the *Cannon Survey Center* at the University of Nevada, Las Vegas for the data collection of the survey. This thesis would not have been possible without the support and funding from the *Water Design-Build Council* for the survey**.**

Furthermore, I would specially like to thank Mr. Sanjib Mulepati for his friendship and moral support. I wish to thank my colleague, Miss Binita Shakya who supported me in data analysis of the survey.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

EVALUATION OF ALTERNATIVE PROJECT DELIVERY METHODS IN WATER AND WASTEWATER PROJECTS

1.1 INTRODUCTION

According to *2013 Report Card for America's Infrastructure* prepared by the American Society of Civil Engineers (ASCE), the United States (U.S.) water municipalities have been facing significant challenges in pipe aging which have resulted in 240,000 water-main breaks per year. The Report shows that both the drinking and wastewater infrastructure are ranked as grade 'D.' In 2012, the American Water Works Association (AWWA) reported that the U.S. needs up to $1.3 trillion in capital investment by the year 2020 to repair and replace the water and wastewater infrastructure. In order to develop an economical approach in water and wastewater projects, affected owners need to focus on use of innovation in design and construction, time and cost savings, and reduced risk among the parties. Alternative project delivery (APD) is a tool that may assist the industry with reaching these goals. Increase in the use of APD methods will only be possible if municipal owners are satisfied with the results in their projects. In this thesis, the *2013 Water Design-Build Council (WDBC) Municipal Owners Satisfaction Survey*, was conducted to determine the owners level of satisfaction with use of the APD methods. The owners were public officials, managers of municipal water/wastewater operations and their professional staffs, and investors of private water companies in the U.S.

1.1.1 Research Objective

The objectives of this research are as follows:

- Determine the owners' satisfaction level with the benefits of Design-Build, Construction Management-at-Risk and Construction Management/General Contractor project delivery methods in water and wastewater projects
- Access the cost and schedule savings experienced by owners
- Compare the statistical median differences in satisfaction level between Utility Manager and Project Staff as well as between Design-Build and Construction Management-at-Risk project delivery method
- Compare mean difference in cost and schedule savings experienced by Utility Manager and Project Staff groups

1.1.2 Scope of the Research

The scope of the study involves collecting and analyzing responses from owners involved in the construction of water and wastewater infrastructure. Survey participants, defined as *Owners,* are public officials and managers of municipal water and wastewater operations and their professional staffs and investors of private water companies in the U.S. The initial list of respondents was received from the Water Design-Build Council (WDBC), the sponsor of this research. The initial list had about 200 contacts and was then supplemented by the research team of the UNLV Department of Civil and Environmental Engineering and Construction by contacting water and wastewater owners all over the U.S. via telephone and email. The survey was sent to 455 prospective participants.

The thesis is presented in manuscript style. Chapters 2 and 3 are presented in a similar form that to be submitted for publication. The survey questionnaire data are used for both chapters. Chapter 2 describes the satisfaction level of different issues related to using APD methods, overall cost and schedule growth, and ranking of reasons for using APD methods. The major impediments of using mainly APD methods in water and wastewater projects were also found. Chapter 3 discusses the statistical differences in satisfaction level, cost and schedule growth, and ranking of reasons for using APD methods among types of respondents and their project delivery experiences. Chapter 4 presents the conclusion and recommendation for future studies.

CHAPTER 2

ALTERNATIVE PROJECT DELIVERY METHODS IN WATER AND WASTEWATER INFRASTRUCTURE

2.1 ABSTRACT

Since the 1990's, the use of Design-Build, Construction Management-at-Risk, and Construction Management/General Contractor as Alternative Project Delivery (APD) methods for water and wastewater projects has significantly increased. Currently, the U.S. municipalities are facing significant challenges in addressing an aging infrastructure that requires replacing and expanding water and wastewater facilities at over 7,000 utilities nationwide. The purpose of this paper is to determine the satisfaction level with various components related to APD methods and the impediments to using these methods in water and wastewater projects. A survey of 455 utility owners was conducted to determine their perceptions about the use of these project delivery methods in the water industry. The results showed that the majority of respondents were satisfied with the various advantages provided by the APD methods. The decision makers and utility owners must overcome the impediments identified by this survey in order to make these project delivery methods more prevalent in the construction of water and wastewater projects.

2.2 BACKGROUND

According to American Water Works Association (AWWA), the U.S. water municipalities have been facing significant challenges with aging pipelines resulting in 240,000 water-main breaks per year (ASCE, 2013). It has been estimated that, by the year 2020, the U.S. needs over $1.3 trillion in capital investment for the repair and replacement of water and wastewater infrastructure in order to maintain adequate delivery of drinking water and treatment of wastewater. An economically sustainable approach in the construction of water and wastewater projects must focus on use of innovation in design and construction, time and cost savings, and equitable distribution of risks among the parties. It is argued that, such approach can be achieved with the use of Alternative Project Delivery (APD) methods, such as Design-Build (DB) and Construction Management-at-Risk (CMAR) and Construction Management/General Contractor (CM/GC).

Design-Bid-Build (DBB) is a traditional method used to design and build water and wastewater projects. In this method, the owner contracts separately with a designer and a contractor (Figure 1). First, the designer prepares complete construction documents for an owner. Then, based on these documents, the contractors bid for the job, and the lowest bid contractor is awarded the project (Lahdenpera, 2001).

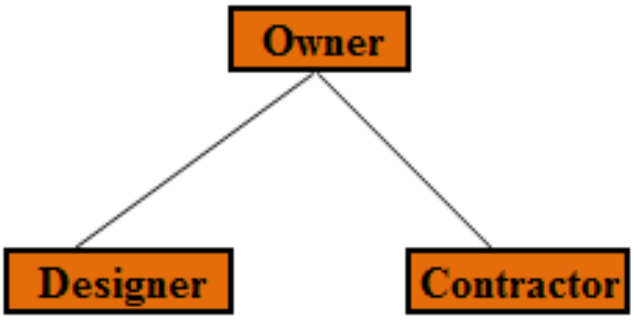


Figure 1. Design-Bid-Build Structure

There are several limitations to the DBB method including the designer's single-point accountability, short-term goals, selection of contractor based on lowest price only, and no involvement of the contractor during the design phase (Miller et al., 2000). In order to overcome these limitations, the various Alternative Project Delivery (APD) methods have been used in construction projects.

Design-Build (DB) is a construction project delivery method in which the designer and the contractor work together in a single company and under a single-point contact (Scatterfield, 2009). Figure 2 shows the structure of a DB project delivery method. The selection of DB method among different types of APD methods also depends on the availability of staff knowledgeable about the related field (Beringer et al., 1999).

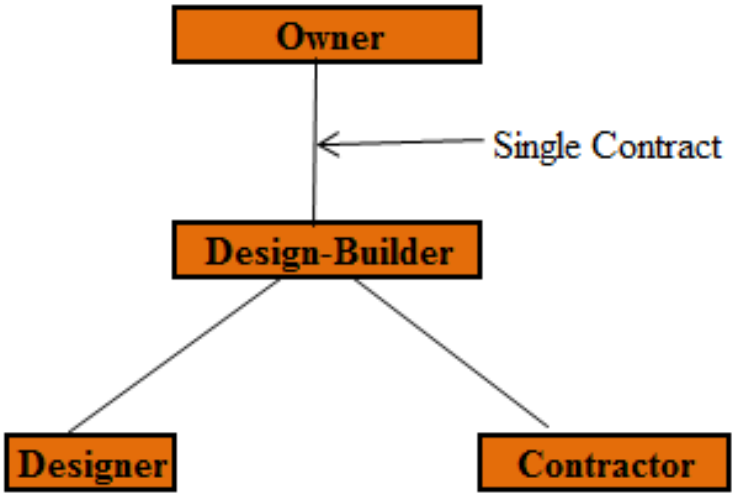


Figure 2. Design-Build Structure

Construction Management-at-Risk (CMAR) is a project delivery method in which the construction manager acts as a consultant to the owner at the pre- construction phases and later as a general contractor taking financial risk during construction under a specified cost agreement. This method integrates the design and the construction phases of a project while contracting separately with the designer and the contractor as shown in Figure 3. CMAR maintains the structure of the contract, like the traditional DBB and also has some of the benefits as DB (Lahdenpera, 2001; Shorney-Darby, Ed., 2012).

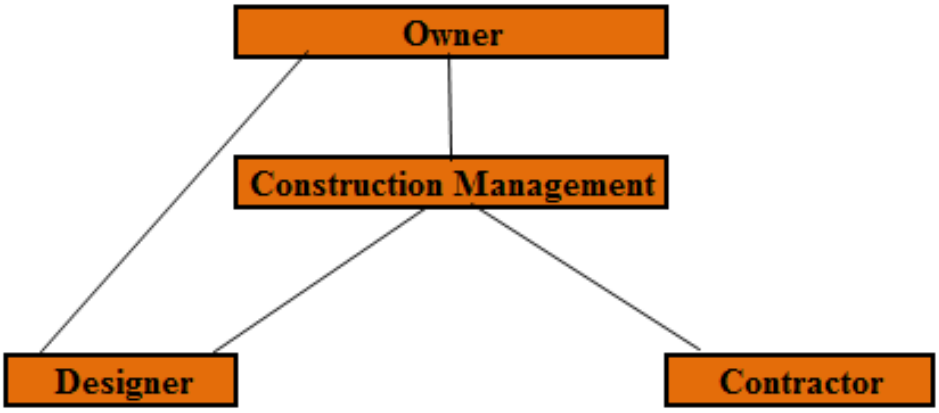


Figure 3. Construction Management-at-Risk Structure

Construction Management/General Contractor (CM/GC) project delivery is a method where all three parties: owner, designer, and contractor collaborate during the early stages of the project (Figure 4). This increases the effectiveness of the project since all parties work together to solve any problems encountered during the project (Flatiron, 2013).

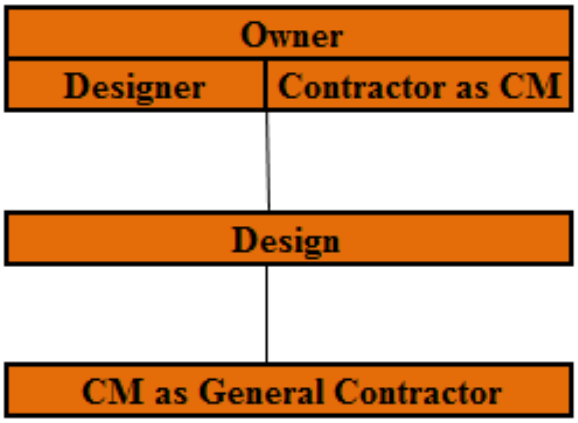


Figure 4. Construction Management/General Contractor Structure

There have been three surveys related to the use of APD methods in water and wastewater projects. The studies were related to finding growth of DB, comparison of DB with traditional DBB method, and benefits of DB in water and wastewater projects. The first study was an industry wide survey conducted by Molenaar et al. (2004) between 2001 and 2002 which showed a rapid growth in the use of DB as the APD method in water and wastewater projects. The author also writes that there are still many water and wastewater projects in different states of the U.S. which still use traditional DBB methods. The second survey conducted by (WDBC, 2009) compared the project performance of DB and DBB project delivery methods in water and wastewater projects. They conducted a questionnaire survey and received responses from 100 public utility owners out of which 31 respondents were involved in DB projects and 69 respondents were involved in DBB projects in between 2003 to 2008. The survey results showed that DB projects had a lower design and construction schedule overrun than DBB projects. Also, DB projects outperformed DBB projects in terms of construction costs spent per month. The third survey was carried out by (WDBC, 2008) for finding the various reasons for using the DB method in water and wastewater projects. A telephone survey was conducted among municipal representatives who were using DB method in their water and wastewater projects. The majority of the respondents of this survey mentioned that the benefits of the DB method were single-point accountability, the contractor's involvement during design, fast delivery of the project, and the high quality of the completed projects.

Other studies conducted on the performance of DB in water and wastewater projects also showed that the main benefits of the DB project delivery method are the singular

responsibility of a DB firm for cost, schedule, and performance. In addition to this, other benefits that have been reported are fast delivery, few change orders, better quality, less owner risk, cost saving, and fewer claims and litigation (Arora 2000; Miller et al., 2000; Scatterfield, 2009). On the other hand, other APD methods such as DBO and DBM had advantages of being a single-point responsibility for construction and operation of the project, lower risks between the involved parties, lower costs, and schedule advantages (Beringer et al., 1999; Culp, 2011).

Success is the major criteria for projects using APD methods in order to increase its use in future projects. Chan et al. (2002) reported that the success of a DB project delivery method depends upon the level of satisfaction of owners and project staffs with timely delivery, quality of completed project, and cost effectiveness of the projects. Moreover, Molenaar et al. (2004) concluded that a DB method can be successfully used in water and wastewater projects by providing proper contract documents, allocating risk to concerned parties, using best value methods to select the DB contractor, and building teamwork between the owner and the contractor. On the other hand, Arora (2000) comments that a DB method can be unsuccessful if the owners do not properly prepare the Request for Proposal (RFP) during the project procurement phase. In addition to this, the author also states that DB methods can be unsuccessful if the focus is not given on the selection of right consultants for the preparation of the contract documents and also if the project does not have clear specifications and goals.

The main goals of Owners are always to save cost and time through innovation by maintaining the quality in their projects. Braid (2011) writes that the technical innovation in design and material selection in APD methods has resulted to cost and time savings maintaining the quality of the project. Besides, White et al. (2005) describes that an innovative use of a smaller footprint facilities design reduced the size, complexity, and adverse effects on the native environment. In case of the cost, mainly DB and DBO project delivery methods have resulted in cost savings for water and wastewater projects. The majority of the respondents (89%) reported that they completed their projects on budget (WDBC, 2008). Also, the cost savings in the Tolt Water Treatment Plant were $70 million when the DBO method was used instead of the conventional DBB method (Kelly et al., 1998). In addition, the DBO design, construction, and operations team for the Lake Pleasant Water Treatment Plant combined with the experience of the city's engineering and operations staff, saved $30 million in comparison to the city's benchmark cost (White et al., 2005). Furthermore, projects using different APD methods were found to have a cost savings when compared to the DBB approach (Culp, 2011). Moreover, WVC (2013) targets a cost saving of 6% and reduction in claims and litigation by 60% in DB projects compared to the traditional approach. On the other hand, Surveys and studies have shown that the owners using DB as an APD method in their water and wastewater projects completed their projects before or on schedule (WDBC, 2008; WDBC, 2009; WVC, 2013; Culp, 2011).

The increase in the use of APD methods will only be possible if the municipal owners are satisfied with its result in their projects. Therefore, a *2013 Water Design-Build Council Municipal Owners Satisfaction Survey* was conducted to determine the owners' level of satisfaction with the use of APD methods in the construction of water and wastewater infrastructure projects. The specific objectives of the survey are:

- Determine the general information such as size, contract procurement, and contractor-selection process used in water and wastewater projects using APD methods
- Measure the level of satisfaction of owners with various benefits related to DB, CMAR and CM/GC project delivery methods
- Access cost and schedule savings in the water and wastewater projects using APD methods

2.3 METHODOLOGY

The survey questions were developed by the researchers based on their knowledge of the water and construction industries. Once prepared, the questions were reviewed by the sponsor, WDBC. After the questions for the survey were decided upon, the survey questionnaire was prepared in Qualtrics Survey Software to be delivered electronically to respondents. The list of respondents include 455 owners (Policy Makers, Utility Managers and Project Staffs) and it included members of WDBC and another 200 respondents identified independently by the research team via phone and e-mail contacts. There existed four categories of questions: (1) Respondents' General Information, (2) Utility Managers/Project Staffs Questions, (3) Policy Maker (Elected/Appointed) Official Questions, and (4) Miscellaneous Questions. The specific questions are shown in appendix. The major questions were related to satisfaction levels with various issues and impediments while using APD methods in the water and wastewater projects. The respondents were asked to quantify the cost and schedule savings they received in their projects that used APD methods. They were also asked to rank the reasons for using APD methods in their projects.

The e-mail survey was sent to respondents and reminders were sent twice. To increase the response rate, phone calls were placed directly to potential respondents. Direct phone contact was found to be very effective in increasing response rate. Qualtrics Survey Software was used to collect data, including data from respondents contact via phone, in SPSS or other spreadsheet format from the questionnaire survey. There were a total of 153 responses representing a 35% response rate. Once the response reached a desired level, the survey was closed and the data was compiled and analyzed.

2.4 RESULTS

Out of the total possible respondents, 153 answered the survey. Descriptive Statistics were used to interpret responses of the survey using Excel. The results obtained from the survey are summarized below.

2.4.1 General Information

Policy Makers, Utility Managers, and Project Staffs who were involved in projects built with APD methods made up the sample of people who responded to the survey. As shown in Figure 5, Project Staffs constituted the highest percentage (54%), followed by Utility Managers (42%) and Policy Makers (4%).

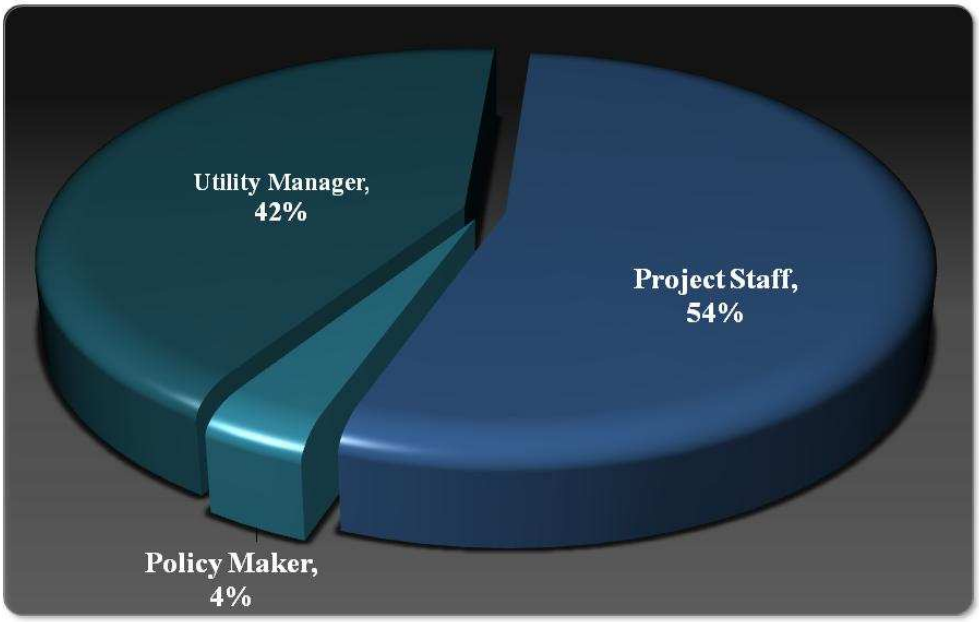


Figure 5. Types of Responsibilities by Percentage (n = 140)

Figure 6 shows that, among the respondents of the survey conducted, 79% had experience in the DB method and 56% had experience in the CMAR method. Furthermore, 27% had experience in the CM/GC method.

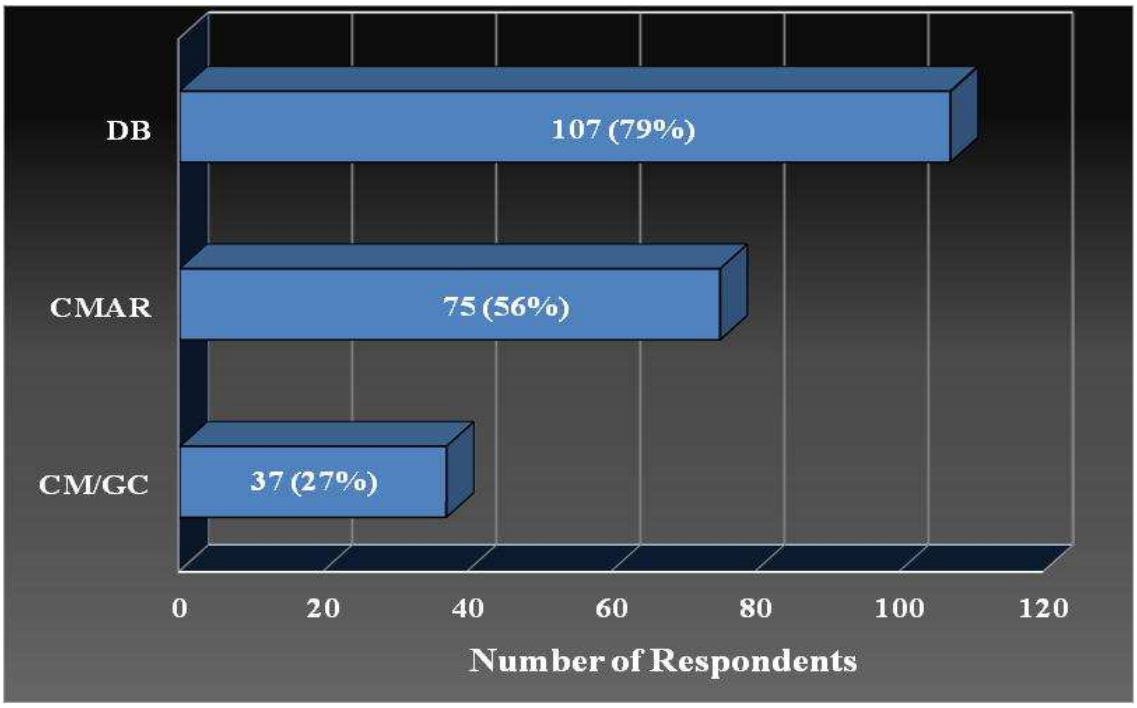


Figure 6. Percentage of Respondents with Project Delivery Experience (n = 135)

The data for the types of projects in which the respondents were involved was also collected. As shown in Figure 7, almost the same numbers of respondents were involved in water treatment plants and wastewater treatment plants, i.e. 50% and 47% respectively. Also, 44% of the respondents were involved in conveyances/pumping station projects, whereas 27% were involved in storage projects. Furthermore, 20% of the respondents were involved in other types of projects such as dams, transportations, and buildings.

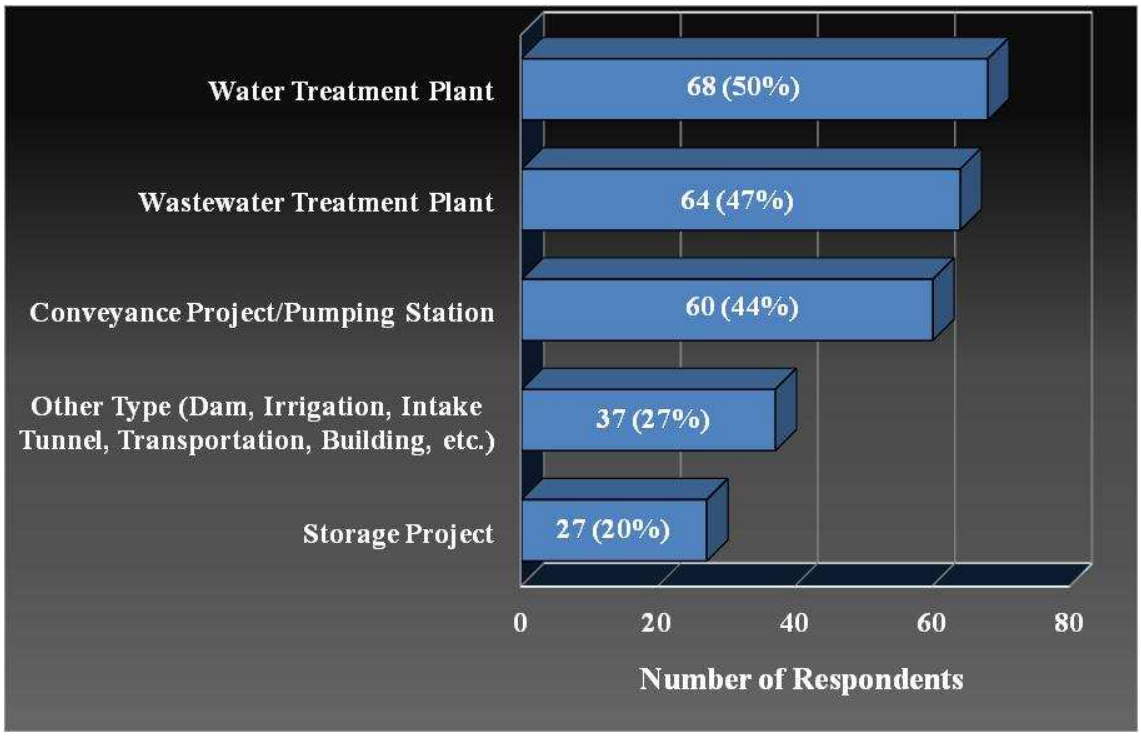


Figure 7. Number of Respondents Involved in Various Types of Projects (n = 136)

The respondents of the survey were asked about the number of projects with their involvement. The majority of the respondents were involved in more than one project. Out of the total respondents, 39% of respondents were involved in more than 5 projects, 44% of the respondents were involved in 2 to 5 projects, and only 17% of the respondents were involved in one project as shown in Figure 8.

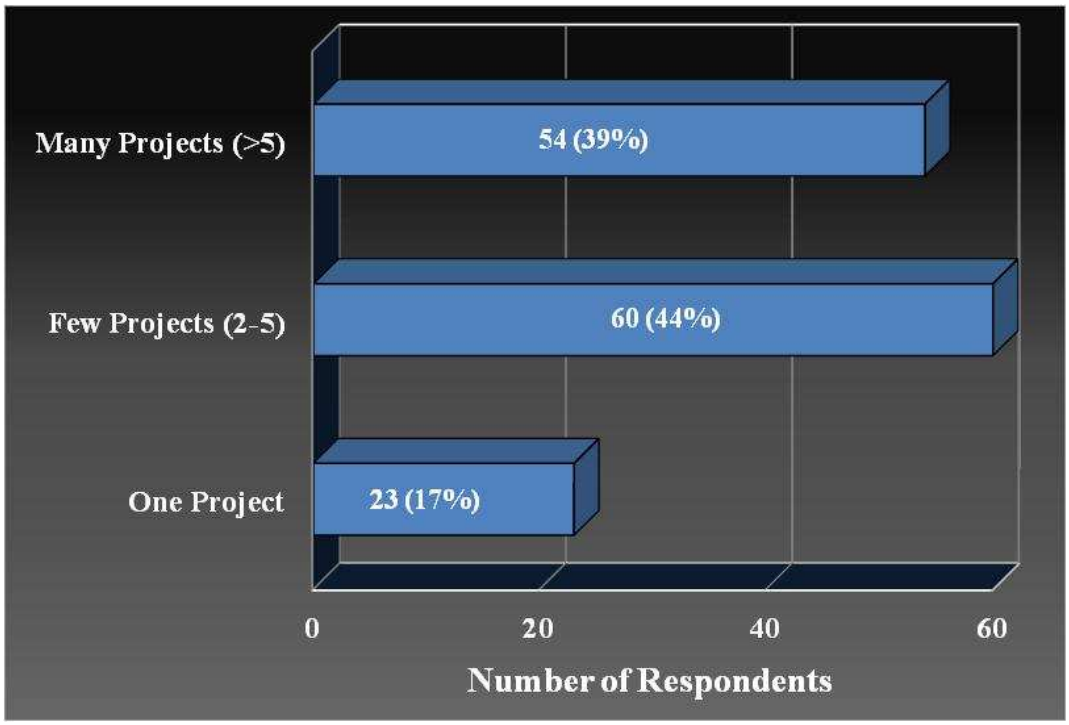


Figure 8. Number of Respondents Involved in Projects Used APD Methods (n = 137)

2.4.2 Project Size, Procurement Process, and Contractor-Selection Methods

The majority of respondents were involved in projects having total project costs between $10M to $100M. The percentage of respondents involved in projects with total project costs less than $10 M, between $10M to $100M, and more than $100M were 25%, 60% and 15% respectively as shown in Figure 9. The results showed that the majority of projects that used APD methods were medium-size projects which are of total project costs between $10M to $100M.

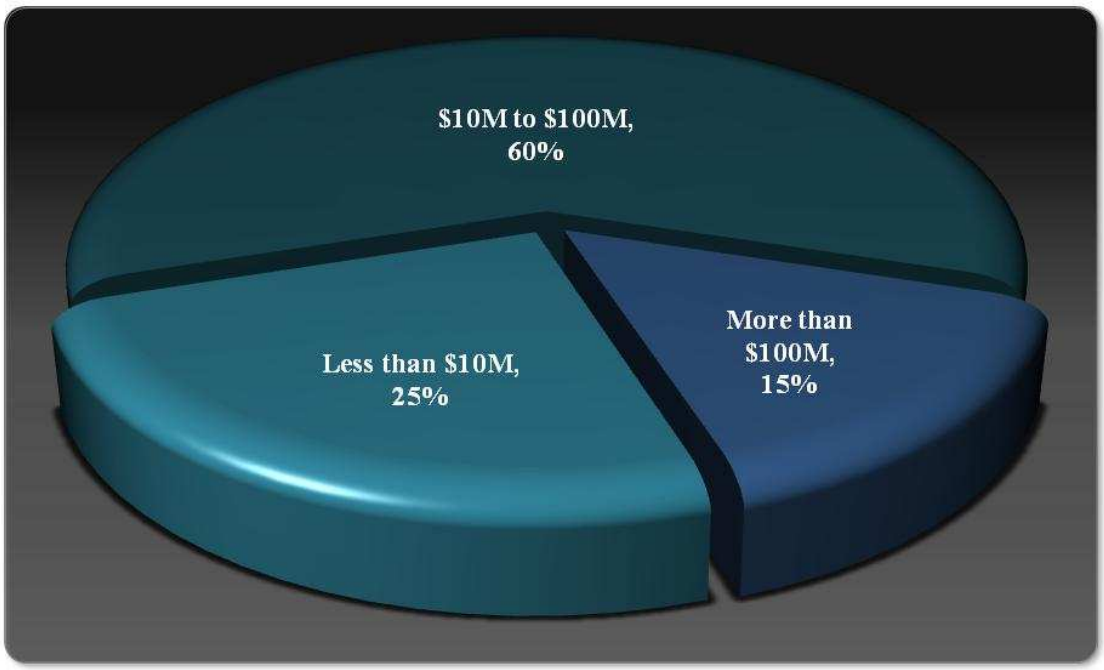


Figure 9. Range of Project Costs by Percentage (n = 132)

As shown in Figure 10, 68% of respondents were involved in a two-step solicitation process known as Request for Qualification and Request for Proposal (RFQ/RFP), whereas 32% of the respondents were involved in a one-step solicitation process known as Request for Proposal (RFP). The results showed that the majority of owners preferred the two-step solicitation process to procure water and wastewater projects using APD methods.

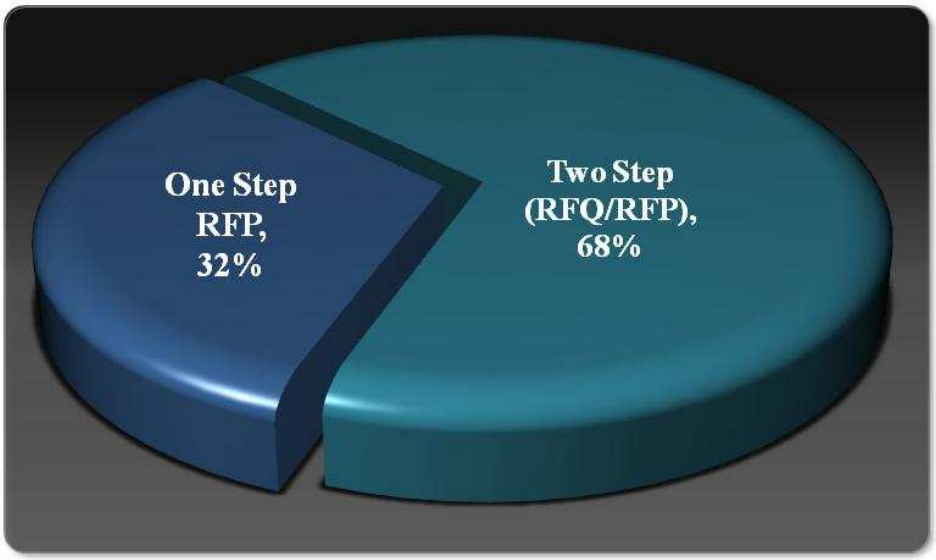


Figure 10. Types of Solicitation Processes by Percentage (n = 132)

The respondents were asked about the contractor-selection criteria they used in their projects. The majority of respondents used Best-Value as the contractor-selection criteria in their projects. Under Best-Value method, both Price and Qualification of contractors is considered during selection of the contract. About 57%, 31% and 12% were used in Best-Value, Qualification only, and Price respectively as a selection criterion in their projects (Figure 11). The results showed that the Best-Value contractor procurement method is the most used in projects built with APD methods.

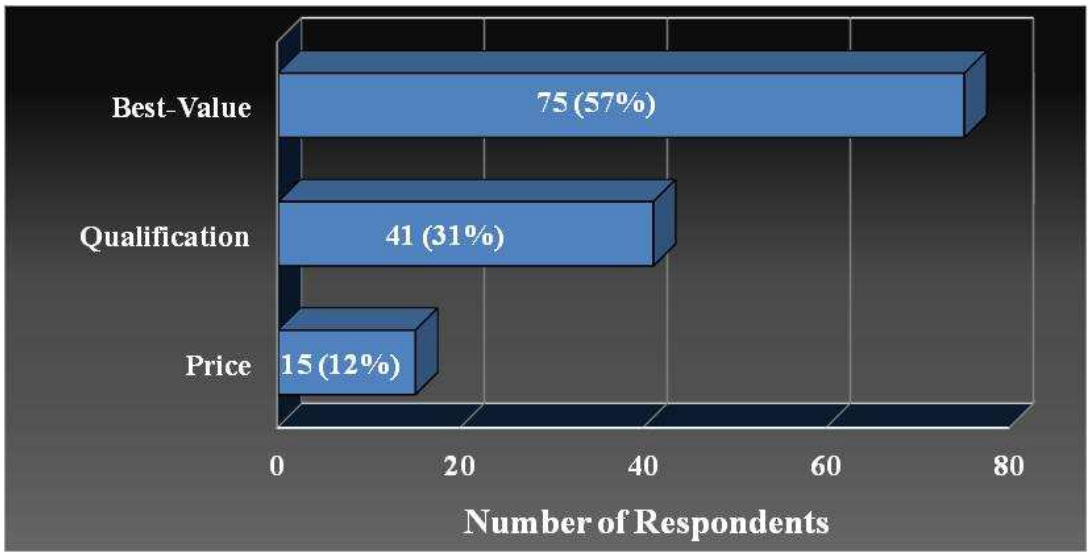


Figure 11. Number of Respondents vs. Contract Selection Criteria (n =131)

2.4.3 Level of Satisfaction with APD Methods

On the survey questionnaire, the respondents were asked to measure their level of satisfaction with owner involvement in design process, project quality, company communication with owner, overall APD experiences, transition to operation of APD projects, risk distribution between owner and company, and their perception of satisfaction of other owners in the range from 1 to 5, with 1 being very unsatisfied and 5 being very satisfied. The mean satisfaction levels of the respondents for all these issues were higher than 4 except for risk distribution between owner and company and respondents' perception of satisfaction of other owners with the use of APD methods (Figure 12). The top three issues that the respondents were highly satisfied with APD methods are the owner's involvement in design process, project quality, company's communication process with owner, and the overall APD method experiences.

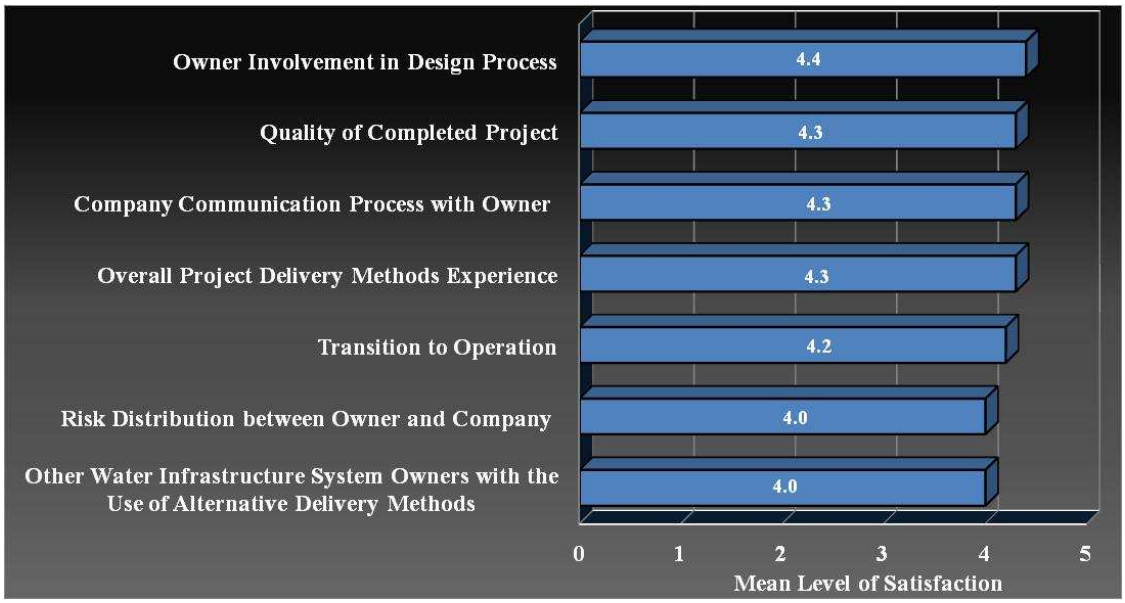


Figure 12. Level of Satisfaction for Various Issues Related to APD Methods

2.4.4 Cost and Schedule Performance of Projects Using APD Methods

The reduction of cost and schedule has always been a main goal of the owner in using APD methods in water and wastewater projects. The respondents were asked to estimate the difference between owner's original cost and schedule estimate and the final completion cost and schedule of their project. As shown in Figure 13 and 14, equal numbers of projects (61% of the projects) had cost and schedule growth of zero or less than zero. The results showed that the majority of the projects built using APD methods were completed at or for less than the owner's estimated cost and schedule.

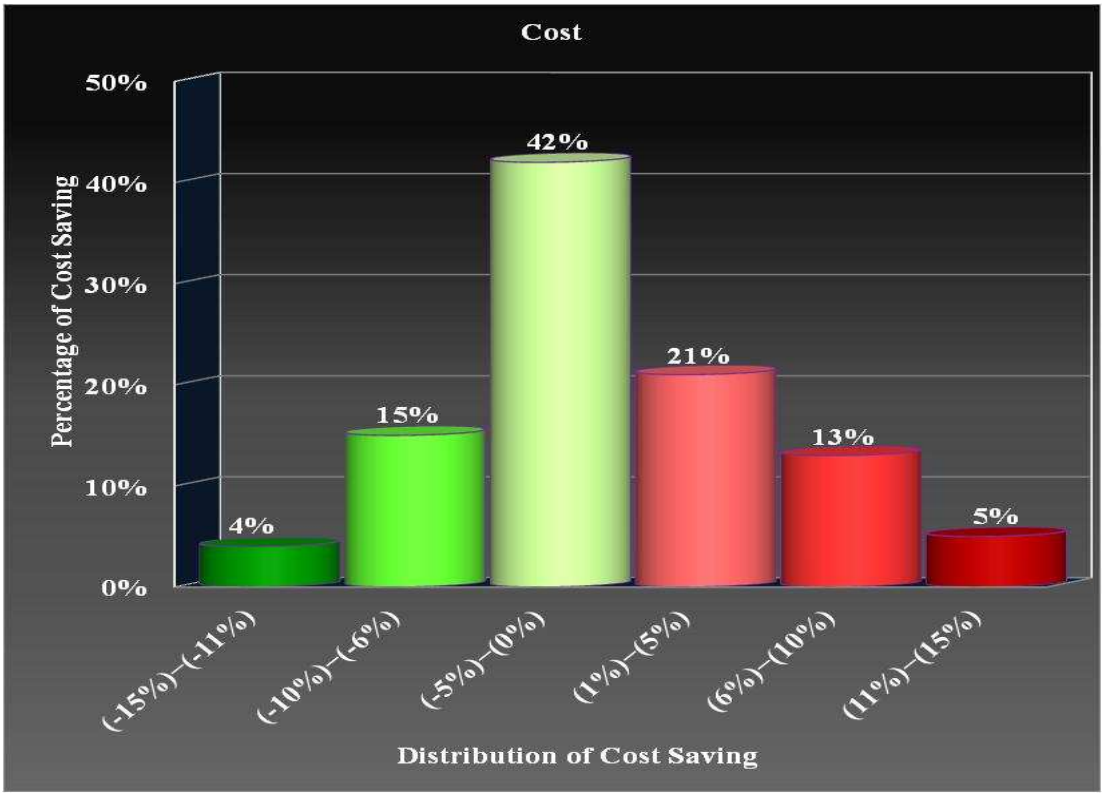


Figure 13. Cost Performance of Projects that Used APD Methods

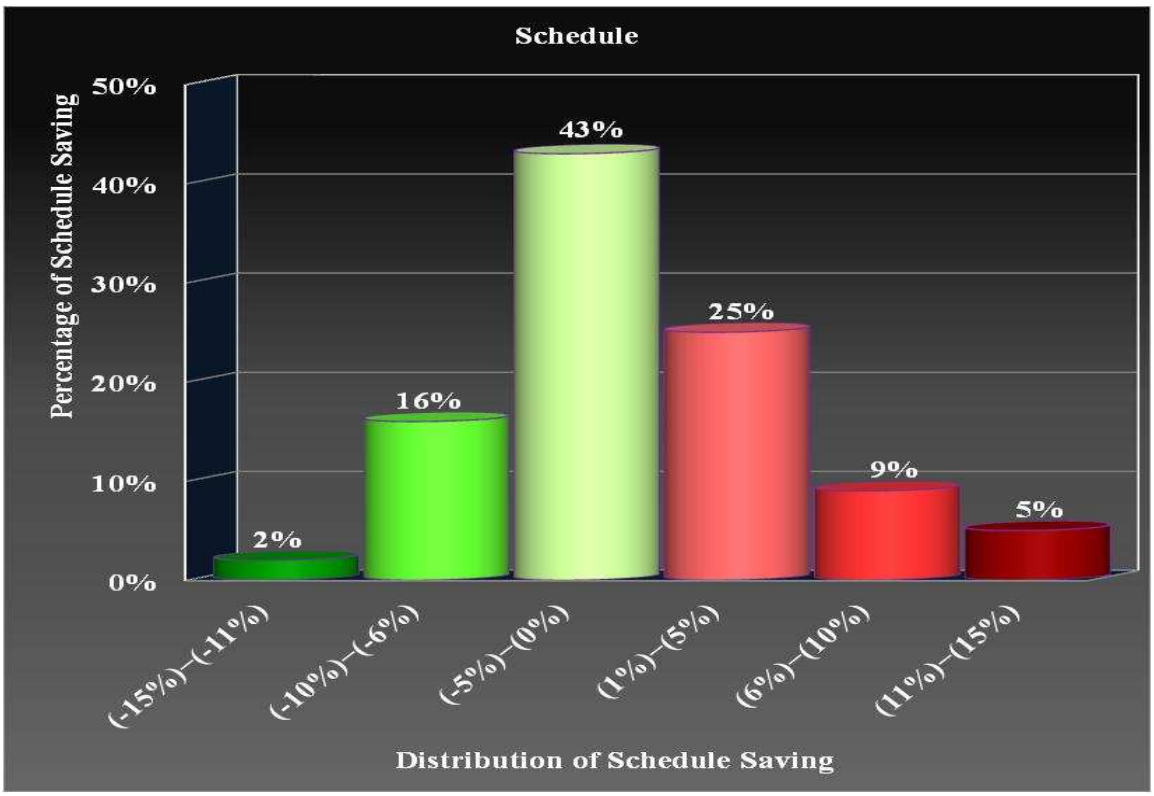


Figure 14. Schedule Performance of Projects that Used APD Methods

2.4.5 Reasons for Using APD Methods in Water and Wastewater Infrastructure

The respondents were asked to rank the reasons of choosing APD methods for their water and wastewater projects, and Figure 15 shows the results. The top three reasons for using APD method in water and wastewater infrastructure were schedule advantage, better quality, and cost advantage from the respondents.

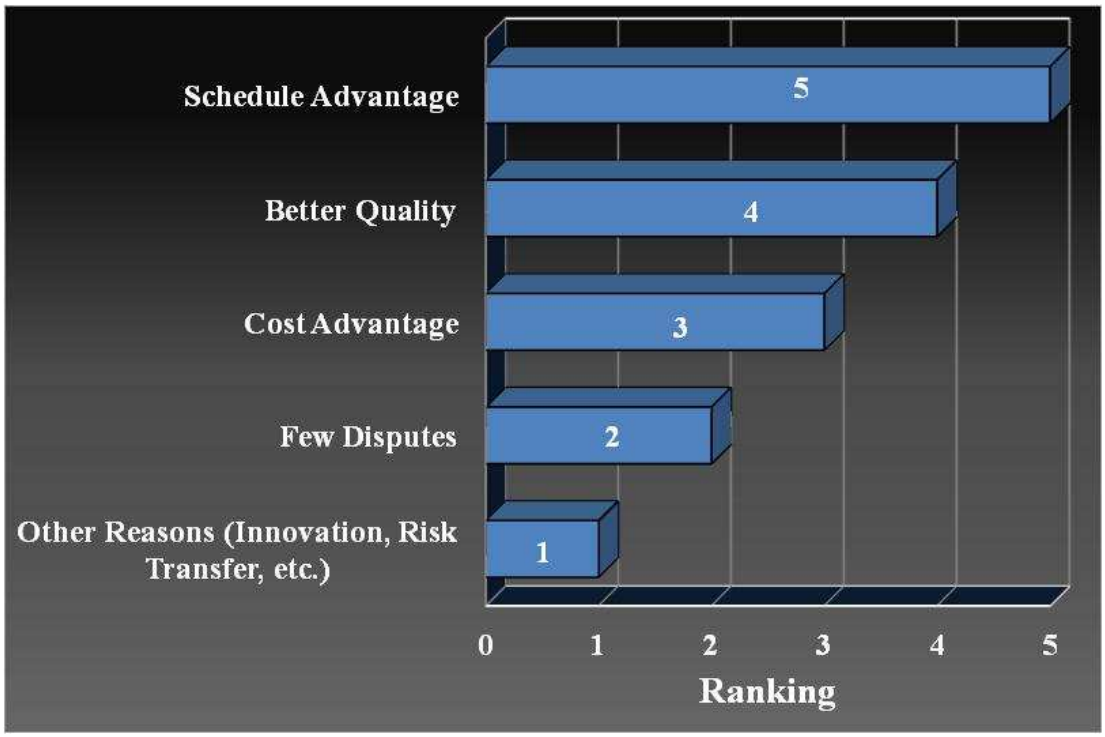


Figure 15. Final Ranking of Reasons that APD Methods were Used (n =128)

In addition, the Utility Managers and Project Staffs were asked whether innovative ideas were used to save money or time or otherwise to improve the quality of their projects. The results showed that the majority of the respondents thought that innovative ideas were used in their projects to save money, time or to improve quality (Figure 16).

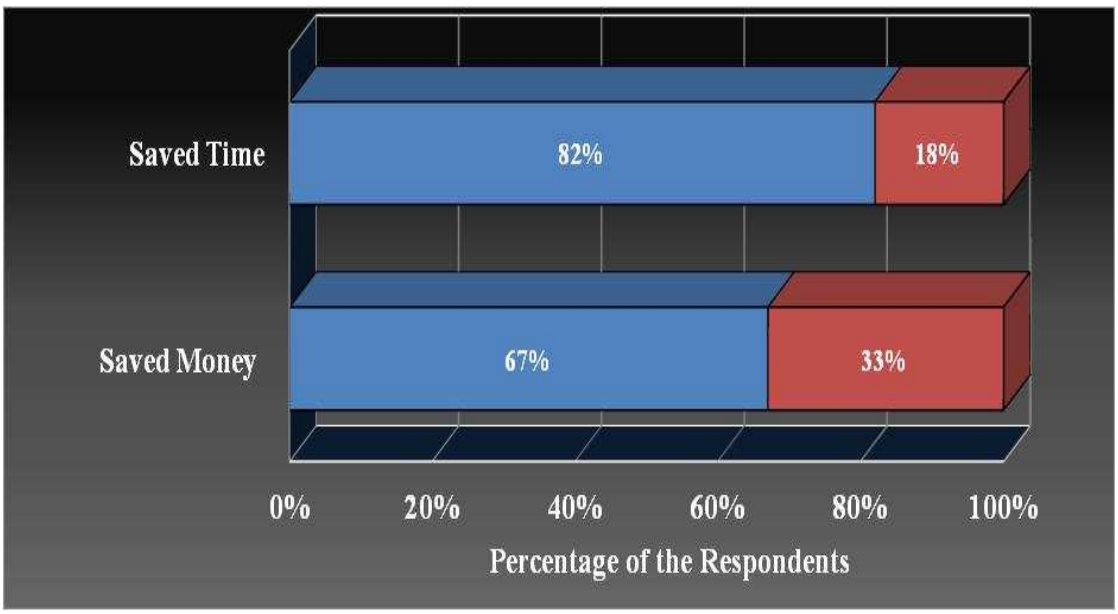


Figure 16. Performance Evaluation of Projects that Used APD Method

2.4.6 Impediments of Using APD Methods

APD methods are in the emerging phase for water and wastewater projects. The owners and firms involved in projects using APD methods experienced significant advantages. The Policy Makers were asked to rank the impediments in using APD methods in water and wastewater projects. The detailed ranking of the impediments in using APD methods is shown in Figure 17. Among various impediments, three main impediments for not using APD methods are unfamiliarity with the process, perception of risk of owner, and resistance to change.

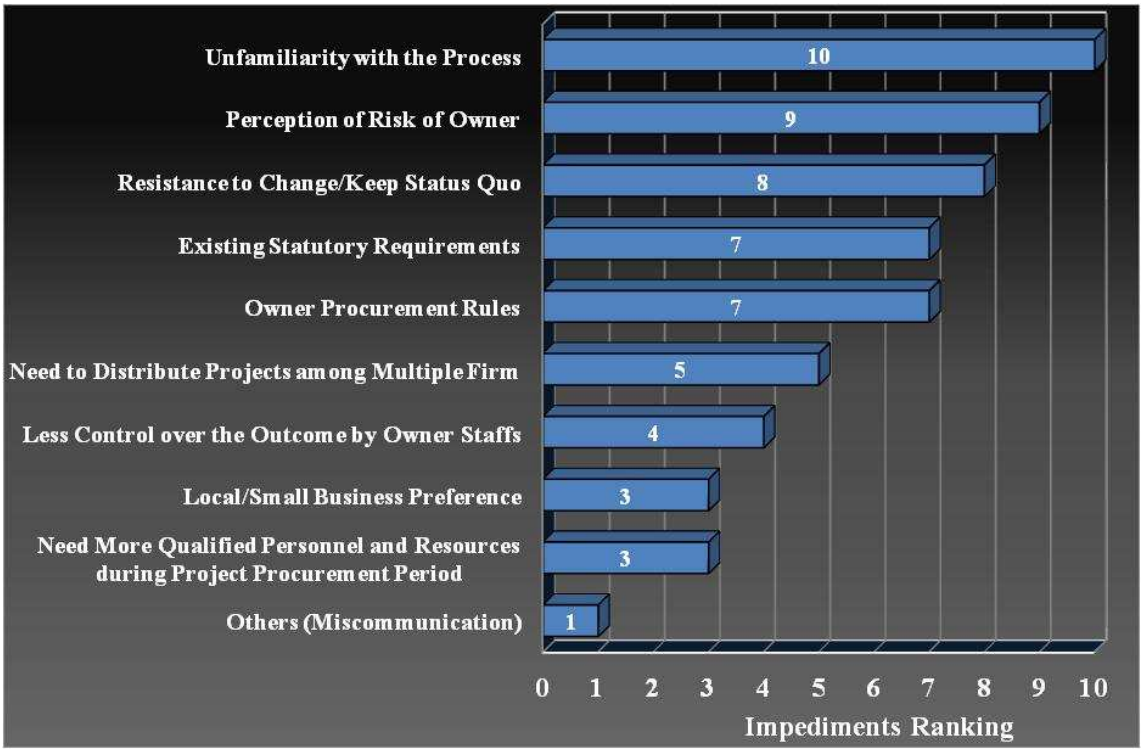


Figure 17. Impediments in Obtaining Public Support and Approvals from Governmental Bodies to Use APD Methods (n = 5)

2.5 KEY FINDINGS OF THE SURVEY

The key findings of the survey are summarized below,

- Survey participants have significant experience with APD methods for water and wastewater infrastructure. A very large percentage (84%) of the respondents has been involved with APD methods in the last ten years.
- A diverse pool of professionals responded to the survey. Project Staffs constituted the highest percentage of participants followed by Utility Managers and Policy Makers.
- The majority of the respondents have experience on DB projects (79%), CMAR (56%), and CM/GC (27%).
- Respondent experiences with APD methods are associated mainly with the construction of water and wastewater treatment plants (47% and 50% respectively) followed by conveyance/pumping stations and water storage, dams, irrigation projects, and canal intakes.
- Project Staffs and Utility Managers are highly satisfied with the use of APD methods in water and wastewater infrastructure construction and would use APD methods again in the future. The survey results show that over 90% of the respondents using APD methods in their projects are either very satisfied or satisfied with the overall experiences.
- The top four items APD methods users are satisfied with are (1) level of the owner's involvement in the design process, (2) quality of completed projects, (3) overall project delivery methods experiences, and (4) the company's communication process with owner. Slightly lower levels of satisfaction were recorded for risk distribution

between owner and company, and perception of other owners' satisfaction with APD methods.

- There exists a general preference for two-step solicitation for procurement of APD methods in water and wastewater infrastructure.
- The survey reveals that most respondents have been involved with medium to large size projects and that Best-Value is the preferred contract selection criteria used in APD for water and wastewater infrastructure.
- The top reasons to use APD methods in water and wastewater infrastructure are schedule advantages, better quality, and cost advantages. Eighty-two percent of respondents agree that APD methods saved time in their projects. About 45% of respondents rank schedule advantages as the most important reason followed by better quality (26 %) and lower cost (13%).
- APD uses in water and wastewater infrastructure result in projects completed below owner's original schedule and cost. When asked to quantify the cost and schedule savings in their projects when using APD methods, about 60% of respondents agreed that the completed cost and schedule of their projects were below owner's original cost and schedule. Overall, 67% of the respondents saved cost in their projects when using APD methods.
- Innovation and better quality are major advantages of using APD methods in water and wastewater infrastructure. A large majority (87%) of the respondents were satisfied with the quality of projects built using APD methods. In addition, 89% of respondents agreed that innovative ideas were used in their projects to save money or time, or to improve quality.

- Water and wastewater projects built using APD methods had significantly fewer disputes and change orders. APD methods use a single contractor to design and construct projects; therefore, the probability is less for having change orders in these types of projects. Large percentages (77%) of the respondents agree that water and wastewater infrastructure built under APD methods had significantly fewer change orders than DBB projects. In addition, a very large majority (82%) agree that APD methods yield less claims and disputes during the construction phase of the projects.
- Owners and firms involved in water and wastewater infrastructure built under APD methods are very satisfied with risk distribution among parties, owner involvement during the design process, and a smooth transition from construction to operation of a project. One potential advantage of using APD methods is the equitable distribution of project risks. About 86% of the respondents are satisfied with the distribution of risks on water and wastewater projects built under APD methods. APD methods should involve the owner in the design process so that the project will be completed successfully. A large majority (94%) of the respondents are satisfied with the involvement of the owner in the design process of these projects. One of the potential advantages of APD methods is the smooth transition of water and wastewater projects from construction to operation. Eighty-six percent of the respondents are satisfied with the transition process of these projects to operation.
- An application of APD methods to water and wastewater infrastructure are still in its infancy and yet significant advantages have been realized by involved owners and firms. There still exist several impediments to broader utilization of APD methods in water and wastewater projects. The top three impediments identified by the Policy

Makers were unfamiliarity with the process, perception of risk by owners, and resistance to change or to keep the status quo.

- Given the many benefits and positive experiences reported, it is expected that the use of APD methods is likely to increase significantly in future years to deliver high quality, innovative, timely, and cost-effective water and wastewater infrastructure.

2.6 CONCLUSION

The results of the survey reveal that the vast majority of Owners and Project Staffs who have been involved with water and wastewater infrastructure using APD methods, are highly satisfied with quality of completed projects, level of owner involvement, communication among involved parties, innovative ideas used, generation of fewer claims or change orders, and smooth transition from constructions to operation of a project. In addition, the survey shows that a majority of respondents prefer a two-step procurement process and a Best-Value as the contractor-selection method. The main reasons for owners' use of APD methods are schedule advantages followed by better quality and lower costs. The major impediments to broader use of APD methods are unfamiliarity with the process, perception of risk by owner, and resistance to change. However, given the many benefits and positive experiences reported, it is expected that the use of APD methods will increase significantly in the future to deliver high quality, innovative, timely, and cost-effective water and wastewater infrastructure. It is recommended that this type of longitudinal study should be carried out in the future to determine the satisfaction level of owners in various issues related to the use of APD methods in water and wastewater projects. It is also recommended that the detailed face-to-face interviews and case studies of projects completed using APD methods should be gathered and reviewed in order to determine the advantages and disadvantages of these methods.

CHAPTER 3

ASSESSING SATISFACTION LEVELS ON THE USE OF ALTERNATIVE PROJECT DELIVERY METHODS IN WATER AND WASTEWATER PROJECTS

3.1 ABSTRACT

There is a need for capital investment of about $1.3 trillion over the next 25 years to repair or replace drinking water-main breaks that occur every year in the United States. Use of Alternative Project Delivery (APD) methods in building, highway, water, and wastewater infrastructure are increasing due to schedule advantages, cost savings, and innovations implemented in a project. This study compares and analyses the difference in the satisfaction level of various benefits of APD methods based on respondents' type and respondents' project delivery method experiences. The respondents included Utility Managers (UM) and Project Staffs (PS) working on Design-Build (DB) and Construction Management-at-Risk (CMAR) projects. The study results showed that PS were significantly more satisfied regarding the quality of project, change orders, and dispute levels compared to UM. In addition, PS experienced significantly higher schedule advantages than UM. When the data was analyzed based on DB and CMAR project delivery experiences, no significant differences were found in the satisfaction levels of APD benefits between these two groups. However, DB users ranked quality advantages significantly higher than CMAR users. Similarly, a significantly higher number of DB users experienced cost advantages in their projects than the CMAR users.

3.2 INTRODUCTION

The United States (U.S.) is facing challenges with aging water and wastewater infrastructure. Most of the underground drinking water infrastructure has reached the end of useful life since they were constructed 50 or more years ago (AWWA, 2012). The study shows that there is a need of the capital investment of $1 trillion for repair and replacement of water infrastructure over next 25 years. The delay in investment may result in water-service degradation, increase in water disruptions, and increase costs in emergency repairs. Both water and wastewater infrastructure were graded "D" by ASCE (2013) in their Report. The Report noted that there are 240,000 drinking water-main breaks per year in U.S. In addition, the Report also states that there is a requirement for capital investment of $298 billion over the next 20 years for the nation's wastewater and storm-water system upgrades.

The limitations of the Design-Bid-Build (DBB) project delivery method are single engineering solution offered by designer, short term goal to spend available funds, selection of a contractor based on lowest bid, and designer not familiar with available construction technologies (Miller et al. 2000). To eliminate these limitations of DBB, it is recommended to shift from the current paradigm toward a new approach that supports the use of APD methods. This new approach is transparent and flexible in terms of financing and managing the projects. APD methods provide a well-defined scope of work at the time of bidding and call for fair contractors' competition based on price and qualification and fulfill a long-term need of the public.

In order to build water and wastewater infrastructure on time and within budget, innovative design and construction technologies should be used in the projects. The

projects built with APD methods generally use these innovations to achieve cost and time savings (Culp 2011). This study was conducted to determine the satisfaction level of the performance of water and wastewater projects built using APD methods. The survey was sent to the respondents who were involved in water and wastewater projects built with APD methods. The survey participants were primarily Utility Managers and Project Staffs of local and regional governmental units (such as utilities, municipalities and water and wastewater districts), as well as a few Policy Makers. The majority of respondents had experiences in Design-Build (DB), Construction Management-at-Risk (CMAR), and Construction Management/General Contractor/ (CM/GC) project delivery methods. The specific objectives of the study are:

- Determine the satisfaction level of various benefits of APD methods
- Estimate the cost and schedule savings the owners experienced in the projects using APD methods
- Compare statistical median difference of satisfaction level of various benefits of APD methods perceived by Utility Managers (UM) and Project Staffs (PS) as well as by DB-experienced and CMAR-experienced respondents
- Compare mean difference in cost and schedule savings experienced between these two groups

3.3 LITERATURE REVIEW

Many researchers have conducted investigations of various projects, such as water, wastewater, building, and highway constructed under different project delivery methods such as DBB, DB, DBO, CMAR, and CM/GC.

3.3.1 Literature Related to Water and Wastewater Projects

Water Design-Build Council (WDBC) conducted a phone survey with 24 municipal representatives who used DB project delivery method in their water and wastewater projects. Majority of the respondents were satisfied with overall quality, schedule advantage, single-point accountability and owner's involvement in DB projects. The survey results showed that 89% of the participants found their DB projects completed on budget and schedule (WDBC, 2008).

A questionnaire survey was conducted with public utility owners to determine the performance of DB and DBB water and wastewater projects built between 2003 and 2008 (WDBC 2009). Thirty-nine DB and 61 DBB projects data were collected from 33 states to compare the performance of these projects. The study found that DB projects had significantly less schedule growth than DBB projects (1 month vs. 2 months). The DB projects were completed significantly earlier than DBB projects (23 months vs. 40 months). In addition, DB project's work intensity was significantly higher than DBB projects ($1.5 million/month versus $0.6million/month).

The use of Design-Build-Operate (DBO) project delivery method in the Seattle Water Filtration project has resulted in cost savings of $70 million in comparison to traditional

DBB method (Kelly et al. 1998). This study concluded that designer and contractor working under a single firm used innovation to reduce project cost.

Braid (2011) concluded that the use of innovation in the project using APD methods in water and wastewater infrastructure has resulted in cost and time savings.

White et al. (2005) conducted a study of a water treatment plant built in Phoenix, Arizona using DBO project delivery method. The benefits of this method were faster delivery of the project, low project costs, low risk of litigation, higher quality of completed project, and use of innovative ideas in the project. The DBO firm designed a number of smaller footprint facilities instead of designing and building a single large footprint facility. This innovation in design resulted in $30 million savings.

3.3.2 Literature Related to Highway and Building Projects

Rojas and Kell (2008) compared 273 DBB and 24 CMAR Pacific Northwest Public schools in Oregon and Washington, and found that bid and cost growth varies depending on the size of the project. The study evaluated the cost effectiveness of the CMAR project delivery method in terms of change order, Guaranteed Maximum Price (GMP) and project cost. The researchers inferred that GMP does not guarantee the cost control. The overall statistical comparison indicated CMAR (4.74%) had lower change order than DBB (6.29%); but when comparison was made on the large projects (greater than $5 million), there was no significant change order growth between DBB (5.3%) and CMAR (6.13%).

Konchar and Sanvido (1998) conducted the study to compare the performance of 351 building projects built using DBB, DB, and CMAR project delivery methods. Among them, projects percentages built using DBB, DB or CMAR were 33%, 44%, and 23%

respectively. The results showed that the unit cost of DB projects was significantly less than that of DBB and CMAR projects by 6.1% and 4.5% respectively. The study results also showed that cost growth of DB projects was significantly less than that of DBB and CMAR projects by 5.2% and 12.6% respectively. In addition, the schedule growth of DB projects was 11.4% less than DBB projects and 21.8% less than CMAR projects. Furthermore, the construction speed of DB projects was 12% faster than DBB projects and 7% faster than CMAR projects. Thus, the study concluded that the DB method has significant advantages over the DBB and CMAR while CMAR has significant advantages over DBB in terms of cost and schedule.

Shrestha et al. (2007) compared project performance in terms of cost, schedule, and change orders of 4 DB and 11 DBB projects. The results showed that the mean cost growth of DB (-5.47%) was significantly lower than that of DBB (4.12%). However, the study did not find any significant difference in schedule growth and change order performance on these two types of projects.

Shrestha et al. (2012) compared the cost, schedule, and change order performance of 16 DBB and 6 DB large highway projects. The study found that the DB projects outperformed DBB projects in terms of project delivery speed (0.5 month/lane mile vs. 2 months/ lane mile) and construction speed (11 days/lane mile vs. 29.4 days/lane mile). However, the study could not find significant differences in cost-related metrics, schedule growth and cost per change order between DB and DBB projects.

3.4 RESEARCH METHODOLOGY

The study methodology consisted of four steps. First the questionnaire was prepared in order to determine the satisfaction level of various benefits of APD methods. Then, the questionnaire was sent to the individuals who were involved in water and wastewater projects built using APD methods. After the data was collected, then it was analyzed using Descriptive Statistics and Statistical Tests using Statistical Package for Social Science (SPSS) 19. At the end, the conclusions of the findings and the recommendations for further study were presented.

3.5 DATA COLLECTION

The questionnaire survey was prepared in collaboration with a team from University of Nevada, Las Vegas and members of Water Design-Build Council. Both parties worked together to include all the questions that measured satisfaction level of various benefits of using APD methods in water and wastewater projects. Te questionnaire was prepared in such a way that the researchers can gather general information about the respondents and the respondents' level of satisfaction with these benefits. The Qualtrics Survey Software was used to design the questionnaire the collected data were downloaded in Statistical Package for Social Science (SPSS) for data analysis.

The data gathered under general information were respondents' name, project location, an involvement in water and wastewater projects using APD methods, type of responsibility, and type of project delivery method experiences. The questions were asked to respondents related to satisfaction level with overall project delivery experiences, quality of completed project, transition to operation, risk distribution between owner and company in their project, company communication process with owner in their project, and level of owner involvement in the design process. The respondents were also asked to estimate the cost and time savings in their projects built using APD methods. In addition, the questions were also asked to determine whether APD methods had lower claims and disputes in compared to DBB projects. Furthermore, the respondents were also asked to rank the reasons for using APD methods in water and wastewater projects.

The questionnaire link was emailed to 455 individuals and followed up with telephone calls. The data was collected between October 1, 2012 and December 14, 2012. More than one third of respondents (35%) from 15 different states responded to the survey.

3.6 DATA ANALYSIS

After the collection of the data, the analysis of data was done using Descriptive Statistics and Statistical Tests. Descriptive Statistics were used to quantitatively describe the main features of the collected data, whereas the Statistical Package for Social Science (SPSS) was used to perform different Statistical Tests in order to make the decisions from the data.

3.6.1 Descriptive Statistics

Descriptive Statistics were used in quantitatively describing and summarizing the main characteristics of the collected data. In this study, the Relative Importance Index (RII) was used to determine the ranking of reasons for using APD methods. The higher value of RII, the more important the reason was for using the APD methods in water and wastewater projects.

RII was calculated using the formula shown in equation 1.

$$\mathrm{RII} = \frac{\sum \mathrm{W}}{(\mathrm{A} * \mathrm{N})} \tag{1}$$

Where, W= weights given to each reason by respondents (ranging from 1 to 5); A= highest weight (i.e., 5 in this case); N = total number of respondents.

The RII value had a range of 0 to 1 (0 not inclusive). RII was used to quantify the importance of delay factors (Gunduz et al., 2013).

3.6.2 Statistical Tests

The Statistical Tests used in this study were Pearson's Chi-Square Test, Parametric Tests, and Non-Parametric Tests. The decision of which Statistical Test to use based on the research design, the distribution of the data, and the type of variable. In general, Parametric Tests were chosen if the data distribution was normal, otherwise Non-Parametric Tests were chosen.

And, the Anderson-Darling Test was conducted to determine whether the population distributions of the dependent variables are normal. A null hypothesis of this Test stated that the population distributions of the dependent variables were normal. If the p-value for this Test was less than or equal to 0.05, then the null hypothesis was rejected confirming that the population distributions were not normal. Some of the Statistical Tests used in this study are described below:

Pearson's Chi-Square Test

Pearson's Chi-Square Test was conducted when the dependent variables were categorical. It was conducted in this study to determine the group difference of some benefits related to APD methods. The null hypothesis for this Test stated that there was no significant difference in responses between two groups. If p-value was less than 0.05, then the null hypothesis was rejected confirming that there was significant difference between two groups' responses.

Mann-Whitney U Test

Mann-Whitney U Test is a Non-Parametric Test. This Test was conducted when the dependent variables were in ordinal scale and the population distributions of the

dependent variables were not normal. It was used in this study to determine the group difference of satisfaction between the respondents' type and the respondents' project delivery method experience. The null hypothesis of this Test was that there was no significant difference between the satisfaction levels of two groups. If the p-value was less than or equal to 0.05, the null hypothesis was rejected confirming the significant group difference.

Analysis of Variance (ANOVA) Test

ANOVA Test is a Parametric Test. This Test was conducted when the dependent variables were in ratio scale, the population distributions of the dependent variables were normal, and the population variances were equal. The ANOVA Test was used to determine the significant differences between the cost and schedule growth estimated by two groups of respondents. The respondents estimated cost and schedule growth in terms of percentages. The null hypothesis of this Test was that the mean cost and the schedule growth of two groups of respondents were not significantly different from each other. The confidence level selected for this data analysis was set at 95%. For the null hypothesis to be false, the p-value must be less than or equal to 0.05. If the null hypothesis was rejected, there was a significant difference between means of two groups.

Levene's Test was conducted to find whether the variances of the population distribution between two groups are equal. The null hypothesis for this Test was that the population variances were equal. If the p-value of Test showed value greater than 0.05 then the null hypothesis was accepted, confirming the sample had equal variances.

3.7 RESULTS

3.7.1 Descriptive Statistics Results

Out of 455 respondents, 153 responded to the questionnaire. The survey responses were received from Utility Managers (UM), Project Staffs (PS), and few Policy Makers working in water and wastewater projects. Some of the respondents did not mention their title in their response. The mean, maximum and minimum rating of overall satisfaction level with the benefits of APD methods are shown in Table 1. Among various benefits of APD methods, the overall maximum and minimum rating observed were 4.4 and 4.0 respectively showing most of the respondents were satisfied with APD methods. The level of owner's involvement in the design process (4.4), quality of completed project (4.3), company's communication process with owner (4.3), and overall project delivery experience (4.3) were the top four benefits of using APD methods.

Table 1

Respondents' Mean Satisfaction Level with Benefits of APD Methods

S.N.	Benefits of APD methods	No of respondents	Level of satisfaction		
			Mean	Maximum	Minimum
1	Owner's involvement in design	98	4.4	5	2
2	Quality of the completed project	107	4.3	5	2
3	Communication process	102	4.3	5	2
4	Overall project delivery experience	105	4.3	5	2
5	Transition to operation	99	4.2	5	2
6	Lower claims and disputes than DBB projects	100	4.2	5	2
7	Risk distribution	91	4.0	5	2
8	Change orders	97	4.0	5	2

The respondents were asked to estimate the percentage difference between owner's original cost and final cost as well as the difference between owner's estimated date of completion and actual completion date of the project. Table 2 shows mean cost and schedule growth percentage estimated by the respondents. The respondents experienced the mean cost growth of 0.13%, whereas the respondents had schedule savings of 0.15%.

Table 2

Cost and Schedule Growth of Projects using APD Methods

S.N.	Cost and schedule performance	No. of respondents	Mean (%)	Maximum (%)	Minimum (%)
1	Cost growth	99	0.13	-15	15
2	Schedule growth	86	-0.15	-12	15

The respondents were asked to rank four major reasons of using APD methods in their water and wastewater projects. Out of the total respondents, 128 individuals ranked their reasons for using APD methods. The Relative Importance Index (RII) of each reason was calculated as shown in Table 3. The result showed that the main reason for choosing the APD method was schedule advantage followed by better quality, cost advantage, and fewer disputes.

Table 3

Overall Ranking of Reasons for Using APD Methods

S.N.	Reasons for using APD methods	RII	Ranks
1	Schedule advantage	0.78	1
2	Better quality	0.69	2
3	Cost advantage	0.65	3
4	Fewer disputes	0.57	4

The respondents were asked about the future reuse of APD methods, their time and cost savings experience, and innovation use in water and wastewater projects. The results showed that 91% of the respondent would use these methods again in their future projects (Table 4). It showed a higher percentage of respondents experienced time savings than cost savings through use of innovation in their projects (82% vs. 67%).

Table 4

Assessment of Benefits of APD Methods

S. N.	Benefits of APD methods	No of respondents	Yes	No
1	Reuse of APD methods	109	91%	9%
2	Innovation used	108	89%	11%
3	Time savings	106	82%	18%
4	Cost savings	107	67%	33%

3.7.2 Statistical Test Results

The responses were subdivided into two groups based on types of respondents and project delivery method experience. The responses were received from 52 UM and 64 PS in the survey. Some of the respondent did not mention their job titles and few respondents were Policy Makers. These two groups of respondents were excluded while conducting the Statistical Test to determine the significance difference in responses of these two groups.

The data were also subdivided based on respondents' project delivery method experience. The respondents had experience on DB, CMAR, and CM/GC project delivery methods. The data of the respondents, who have CM/GC experience, were combined into CMAR group because CM/GC project delivery method is similar to CMAR project delivery method. Thirty-seven and 40 respondents had DB and CMAR project delivery method experience respectively. Some respondents had experience on both DB and CMAR projects. These respondents' data were excluded from this analysis. All the respondents did not respond to all the questions asked in the questionnaire. Therefore, the number of respondents in each question could be less than these numbers.

3.7.2.1 Comparison of Satisfaction Levels of UM and PS

Results of Comparison of Satisfaction Level

The Anderson-Darling Test was conducted for all the dependent variables based on respondents' type to determine whether the population distribution is normal. The result showed that all the dependent variables' population distribution is not normal since the p-value was less than 0.05 (Table 5).

Table 5

Anderson–Darling Test Results of Satisfaction Level by Respondents' Types

S. N.	Benefits of APD methods	Respondents type	ADT statistics	p-value
1	Overall project delivery experience	Utility Manager	3.96	<0.01*
		Project Staff	6.75	<0.01*
2	Quality of the completed project	Utility Manager	3.54	<0.01*
		Project Staff	7.28	<0.01*
3	Transition to operation	Utility Manager	3.48	<0.01*
		Project Staff	5.32	<0.01*
4	Risk distribution	Utility Manager	3.93	<0.01*
		Project Staff	7.82	<0.01*
5	Communication process	Utility Manager	3.28	<0.01*
		Project Staff	5.78	<0.01*
6	Owner's involvement in design	Utility Manager	7.76	<0.01*
		Project Staff	5.56	<0.01*
7	Change orders	Utility Manager	3.66	<0.01*
		Project Staff	5.29	<0.01*
8	Lower claims and disputes than DBB projects	Utility Manager	3.63	<0.01*
		Project Staff	6.12	<0.01*

*Significant at alpha level 0.05

As the dependent variables were in ordinal scale and their population distributions were not normal, the Mann-Whitney U Test was conducted to determine significant group difference in their satisfaction level with the benefits of the APD methods. The result showed that there is a significant difference in satisfaction level between UM and PS related to quality of the project completed, change order, and claims and disputes (Table 6). The result showed that PS are significantly more satisfied than UM with APD benefits related to quality (Median rank 59 vs. 48), change order (Median rank 55 vs. 43) and claim and disputes vs. DBB method (Median rank 55 vs. 45). The satisfaction levels related to other issues were not significantly different between PS and UM since their p-value is greater than 0.05.

Table 6

Mann-Whitney U Test Results by Respondents' Types

S. N.	Benefits of APD methods	Respondents type	No. of sample	Mean satisfaction	Median rank	p-value
1	Overall project delivery experience	Utility Manager	47	4.2	52	0.49
		Project Staff	60	4.3	56	
2	Quality of the completed project	Utility Manager	46	4.2	48	0.05*
		Project Staff	61	4.5	59	
3	Transition to operation	Utility Manager	41	4.3	52	0.51
		Project Staff	58	4.2	49	
4	Risk distribution	Utility Manager	39	4.0	49	0.46
		Project Staff	53	3.9	45	
5	Communication process	Utility Manager	44	4.1	48	0.27
		Project Staff	59	4.3	55	
6	Owner's involvement in design	Utility Manager	44	4.5	52	0.48
		Project Staff	55	4.3	48	
7	Change orders	Utility Manager	44	3.8	43	0.03*
		Project Staff	54	4.1	55	
8	Lower claims and disputes than DBB projects	Utility Manager	44	4.0	45	0.05*
		Project Staff	56	4.3	55	

*Significant at alpha level 0.05

Results of Comparison of Ranking of Reasons Using APD Methods

The RIIs was calculated to determine the ranking of the reasons based on UM and PS responses. Table 7 shows the ranking of the reasons for using APD methods for these two types of respondents. Both groups ranked schedule, followed by quality, cost, and fewer disputes as the top four advantages of APD methods.

Table 7

Ranking of Reasons for Using APD Methods Based by Respondents' Types

S.N.	Reasons for using APD methods	Utility Managers		Project Staffs	
		RII	Ranking	RII	Ranking
1	Schedule advantage	0.76	1	0.81	1
2	Better quality	0.68	2	0.72	2
3	Cost advantage	0.65	3	0.63	3
4	Fewer disputes	0.55	4	0.58	4

The Anderson-Darling Test was conducted to determine whether the population distribution of the dependent variables based on types of respondents were normal. The results of this Test showed that the populations distributions of these variables are not normal since their p-values observed were less than 0.05 (Table 8).

Table 8

Anderson-Darling Test Results for Reasons Using APD Methods by Respondents' Types

S.N.	Reasons for using APD methods	Respondent types	ADT value	p-value
1	Cost advantage	Utility Manager	1.83	<0.01*
		Project Staff	2.81	<0.01*
2	Schedule advantage	Utility Manager	3.80	<0.01*
		Project Staff	5.61	<0.01*
3	Better quality	Utility Manager	1.99	<0.01*
		Project Staff	2.76	<0.01*
4	Fewer disputes	Utility Manager	2.58	<0.01*
		Project Staff	3.71	<0.01*

* Significant at alpha value 0.05

The Mann-Whitney U Test was conducted to determine significance difference in UM and PS ranking of the reasons using APD methods. The results showed there is no significant difference observed between their responses as their p-values were greater than 0.05 (Table 9). It showed that both groups' ranking for the reasons for using APD methods in their projects were similar.

Table 9

Mann-Whitney U Test Results of Ranking of Reasons by Respondents' Types

S.N.	Reasons for using APD methods	Respondents type	No. of sample	Median rank	p-value
1	Cost advantage	Utility Manager	52	61	0.49
		Project Staff	64	57	
2	Schedule advantage	Utility Manager	52	55	0.35
		Project Staff	64	62	
3	Better quality	Utility Manager	52	56	0.42
		Project Staff	64	61	
4	Fewer disputes	Utility Manager	52	57	0.45
		Project Staff	64	60	

*****Significant at alpha level 0.05

Results of Comparison of Cost and Schedule Growth

The ANOVA Test was conducted to determine the significance difference between the cost and schedule growth of projects using APD methods based on types of respondents. This Test was conducted because the dependent variables were on a ratio scale. One of the major assumptions of the ANOVA Test is the population distribution of the dependent variables must be normal. The Anderson-Darling Test was conducted to determine the normality of the population distribution. Table 10 shows the result of Anderson-Darling Test. The Test results showed that the distribution of the dependent variables were normal, because the p-values of the Test were greater than 0.05.

Table 10

Anderson-Darling Test Results for Cost and Schedule Growth by Respondents' Types

S.N.	Cost and schedule performance	Respondents type	ADT value	p-value
1	Cost growth	Utility Manager	0.32	0.53
		Project Staff	0.55	0.15
2	Schedule growth	Utility Manager	0.60	0.11
		Project Staff	0.59	0.12

*****Significant at alpha level 0.05

Another assumption of the ANOVA Test is that the variances of the population distribution for both groups are equal. Levene's Test was conducted to determine whether the samples had equal variances. The null hypothesis of this Test is that the samples have equal variances. The null hypothesis will be accepted if the p-value of the Test is more than 0.05. The Test results showed that the p-value of both cost and schedule growth are more than 0.05 confirming these dependent variables have equal variances (Table 11).

Table 11

Levene Test Results of Homogeneity of Variance by Respondents' Types

S.N.	Cost and schedule performance	Levene statistics	p-value
1	Cost growth	0.49	0.49
2	Schedule growth	0.05	0.82

*****Significant at alpha level 0.05

The ANOVA Test was conducted to determine the significant difference between the cost and schedule growth estimated by the UM and PS. Table 12 shows the results of this Test. The results showed that there is a significant difference between the schedule growth estimated by UM and PS. UM estimated that on average the projects were completed 1.38% behind the schedule, whereas PS estimated that on average their projects were completed 1.15% ahead of the schedule. However, no significant difference in cost savings estimated by UM and PS were found. PS experienced cost savings of 0.16% whereas UM experienced cost growth by 0.54% in their projects.

Table 12

ANOVA Test Results of Cost and Schedule Growth by Respondents' Types

S.N.	Cost and schedule performance	Respondents type	No. of sample	Mean (%)	p-value
1	Cost growth	Utility Manager	41	0.54	0.62
		Project Staff	58	-0.16	
2	Schedule growth	Utility Manager	34	1.38	0.04*
		Project Staff	52	-1.15	

*****Significant at alpha level 0.05

Results of Pearson's Chi-Square Test

The respondents were asked whether they receive the benefits of APD methods in their water and wastewater projects. The responses of these questions were in "Yes" and "No" modes. Therefore, Pearson's Chi-Square Test was conducted to determine the difference between the group responses. The results of Pearson's Chi-Square Test are shown in Table 13. The majority of UM and PS thought that innovation was used in their projects. In addition to this, the majority of respondents saved time and money in their projects using APD methods and they were willing to reuse this method again in another project. However, the p-values for all the four responses are higher than 0.05, confirming that it failed to reject null hypothesis. Therefore there is no significant difference in the responses provided by UM and PS. The results also showed that more respondents agreed that they saved time rather than money in their projects by using APD methods.

Table 13

Pearson's Chi-Square Test Results by Respondents' Types

S.N.	Benefits of APD methods	Respondents type	Yes	No	Pearson's Chi-Square value	p-value
1	Innovation used	Utility Manager	91%	9%	0.47	0.49
		Project Staff	87%	13%		
2	Cost savings	Utility Manager	61%	39%	1.51	0.22
		Project Staff	72%	28%		
3	Time savings	Utility Manager	84%	16%	0.29	0.59
		Project Staff	80%	20%		
4	Reuse of APD methods	Utility Manager	87%	13%	1.43	0.23
		Project Staff	94%	6%		

*Significant at alpha level 0.05

3.7.2.2 Comparison of Satisfaction Level of DB & CMAR Project Delivery Users

Results of Comparison of Satisfaction Level

The Anderson-Darling Test was conducted for all the dependent variables based on respondents' project delivery method experience to determine whether the population distribution is normal. The results showed that all the dependent variables' population distribution is not normal since the p-value was less than 0.05 (Table 14).

Table 14

Anderson–Darling Test Results of Satisfaction Level of Respondents' Project Delivery Method Experience

S.N.	Benefits of APD methods	Project delivery experience	ADT statistics	p-value
1	Overall project delivery experience	DB	3.32	<0.01*
		CMAR	1.41	<0.01*
2	Quality of the completed project	DB	3.29	<0.01*
		CMAR	1.73	<0.01*
3	Transition to operation	DB	2.24	<0.01*
		CMAR	1.92	<0.01*
4	Risk distribution	DB	3.20	<0.01*
		CMAR	2.26	<0.01*
5	Communication process	DB	3.04	<0.01*
		CMAR	1.36	<0.01*
6	Owner's involvement in design	DB	3.11	<0.01*
		CMAR	2.28	<0.01*
7	Change orders	DB	2.34	<0.01*
		CMAR	1.07	<0.01*
8	Lower claims and disputes than DBB projects	DB	2.69	<0.01*
		CMAR	1.27	<0.01*

*****Significant at alpha level 0.05

As the dependent variables were in ordinal scale and their population distributions were not normal, the Mann-Whitney U Test was conducted to determine significance group difference in their satisfaction level regarding the benefits of the APD methods. Most of the DB project delivery users were satisfied with APD benefits as compared to CMAR. The results showed that there is no significant difference in satisfaction level of DB and CMAR project delivery users since p-values for all cases were greater than 0.05 (Table 15).

Table 15

Mann-Whitney U Test Results by Respondents' Project Delivery Method Experience

S.N.	Benefits of APD methods	Project delivery experience	No. of sample	Mean satisfaction	Median rank	p-value
1	Overall project delivery experience	DB	37	4.2	31	0.22
		CMAR	20	3.7	26	
2	Quality of the completed project	DB	36	4.3	30	0.50
		CMAR	20	4.1	27	
3	Transition to operation	DB	31	4.1	25	0.90
		CMAR	19	4.2	26	
4	Risk distribution	DB	31	4.0	28	0.06
		CMAR	18	3.5	21	
5	Communication process	DB	35	4.1	28	0.51
		CMAR	19	3.7	26	
6	Owner's involvement in design	DB	32	4.3	26	0.90
		CMAR	20	4.3	27	
7	Change orders	DB	32	4.1	27	0.18
		CMAR	17	3.6	22	
8	Lower claims and disputes than DBB projects	DB	34	4.1	28	0.26
		CMAR	17	3.6	23	

*****Significant at alpha level 0.05

Results of Comparison of Ranking of Reasons Using APD Methods

The RIIs was calculated to determine the ranking of the reasons based on DB and CMAR project delivery user's data. Table 16 shows the ranking of the reasons for using APD methods for these two types of respondents. The ranking of the reasons for these two groups were similar for schedule advantage (ranked highest) and fewer disputes (ranked lowest) as advantage of APD methods. DB project delivery users ranked better quality as second but CMAR project delivery users ranked cost advantage as second.

Table 16

Ranking of Reasons for Using APD Methods Based by Respondents' Project Delivery Method Experience

S.N.	Reasons for using APD methods	DB experience		CMAR experience	
		RII	Ranking	RII	Ranking
1	Schedule advantage	0.78	1	0.79	1
2	Better quality	0.69	2	0.62	3
3	Cost advantage	0.66	3	0.78	2
4	Fewer disputes	0.55	4	0.60	4

The Anderson-Darling Test was conducted to determine whether the population distribution of the dependent variables based on respondents' project delivery method experience was normal. The results of this Test showed that the population distributions of these variables are not normal since their p-values were less than 0.05 (Table 17).

Table 17

Anderson-Darling Test Results for Reasons Using APD Methods by Respondents' Project Delivery Method Experience

S.N.	Reasons for using APD methods	Project delivery experience	ADT value	p-value
1	Cost advantage	DB	1.74	<0.01*
		CMAR	1.19	<0.01*
2	Schedule advantage	DB	3.38	<0.01*
		CMAR	2.46	<0.01*
3	Better quality	DB	1.75	<0.01*
		CMAR	1.43	<0.01*
4	Fewer disputes	DB	2.36	<0.01*
		CMAR	1.63	<0.01*

* Significant at alpha value 0.05

The Mann-Whitney U Test was conducted to determine significant difference in DB and CMAR project delivery users ranking of the reasons using APD methods. The result shows that there is a significance difference in ranking of better quality between them (Table 18). The respondents of DB project delivery user ranked quality higher than CMAR users as a reason for using APD methods. It showed that both groups' ranking for other reasons for using APD methods in their projects were similar.

Table 18

Mann-Whitney U Test Results of Ranking of Reasons by Respondents' Project Delivery Method Experience

S.N.	Reasons for using APD methods	Project delivery experience	No. of sample	Median rank	p-value
1	Cost advantage	DB	41	37	0.13
		CMAR	26	30	
2	Schedule advantage	DB	41	34	0.87
		CMAR	26	34	
3	Better quality	DB	41	30	0.03*
		CMAR	26	40	
4	Fewer disputes	DB	41	32	0.25
		CMAR	26	37	

*****Significant at alpha level 0.05

Results of Comparison of Cost and Schedule Growth

The ANOVA Test was conducted to determine the significant difference between the cost and schedule growth of projects using APD methods based on respondents' project delivery method experience. This Test was conducted because the dependent variables were on a ratio scale. One of the major assumptions of the ANOVA Test is that the population distribution of the dependent variables must be normal. The Anderson-Darling Test was conducted to determine the normality of the population distribution. Table 19 shows the result of Anderson-Darling Test. The Test results showed that the distribution of the both the dependent variables were normal, because the p-value of the Test was greater than 0.05 except for DB project delivery method user responses in schedule growth.

Table 19

Anderson-Darling Test Results for Cost and Schedule Growth by Respondents' Project Delivery Method Experience

S.N.	Cost and schedule performance	Project delivery experience	ADT value	p-value
1	Cost growth	DB	0.43	0.28
		CMAR	0.29	0.59
2	Schedule growth	DB	0.91	0.02*
		CMAR	0.13	0.98

*****Significant at alpha level 0.05

Another assumption of the ANOVA Test is that the variances of the population distribution for all the groups are equal. Levene's Test was conducted to determine whether the samples had equal variances. The Test results showed that the p-value of both cost and schedule growth are more than 0.05 confirming these dependent variables have equal variances (Table 20).

Table 20

Levene Test Results of Homogeneity of Variance by Respondents' Project Delivery Method Experience

S.N.	Cost and schedule performance	Levene statistics	p-value
1	Cost growth	2.64	0.11
2	Schedule growth	0.24	0.62

*****Significant at alpha level 0.05

The ANOVA Test was conducted to determine the significant difference between the cost and schedule growth estimated by the DB and CMAR project delivery users. Table 21 shows the results of this Test. The results showed that there is no significant difference between the schedule growth estimated by DB and CMAR project delivery users since p-value is more than 0.05. The mean cost growth observed by DB project delivery users was less than CMAR project delivery users (0.21% vs. 2.44%). Also, the DB project delivery users experience less schedule growth than CMAR project delivery users (0.65% vs. 1.06%).

Table 21

ANOVA Test Results of Cost and Schedule Growth by Respondents' Project Delivery Method Experience

S.N.	Cost and schedule performance	Project delivery experience	No. of sample	Mean (%)	p-value
1	Cost growth	DB	34	0.21	0.25
		CMAR	18	2.44	
2	Schedule growth	DB	31	0.65	0.83
		CMAR	16	1.06	

*****Significant at alpha level 0.05

Results of Pearson's Chi-Square Test

The respondents were asked whether they receive the benefits of APD methods in their water and wastewater projects. The responses of these questions were in "Yes" and "No" modes. Therefore, the Pearson's Chi-Square Test was conducted to determine the difference between the group responses. The results of Pearson's Chi-Square Test are shown in Table 22. There is a significant difference in responses between the DB and CMAR project delivery users in cost savings. A significantly higher number DB project delivery users experienced cost savings than CMAR project-delivery users in their projects (86% vs. 37%). All other cases have the p-values more than 0.05 confirming they were not significantly different with each other. The results show that the majority

of respondents are in favor of reusing the APD methods in future. More DB project delivery users saved time by using innovation than CMAR project-delivery users.

Table 22

Pearson's Chi-Square Test Results by Respondents' Project Delivery Method Experience

S.N.	Benefits of APD methods	Project delivery experience	Yes	No	Pearson's Chi-Square value	p-value
1	Innovation used	DB	86%	14%	1.40	0.24
		CMAR	74%	26%		
2	Cost savings	DB	86%	14%	13.64	0.01*
		CMAR	37%	63%		
3	Time savings	DB	84%	16%	0.81	0.37
		CMAR	74%	26%		
4	Reuse of APD methods	DB	89%	11%	3.13	0.08
		CMAR	70%	30%		

*Significant at alpha level 0.05

3.8 CONCLUSION

The study measured respondents' satisfaction level with benefits of APD methods, estimated cost and schedule growth, ranked reasons for using APD methods and assessed benefits of APD methods. The survey responses were received from Utility Managers, Project Staffs, and Policy Makers involved in projects using DB, CMAR, and CM/GC project delivery methods in the water and wastewater projects. The majority of the respondents were satisfied with different issues of APD methods. The top four benefits of using APD methods were the level of owner's involvement in the design process, quality of completed project, company's communication process with owner, and overall project delivery experience. On average, the respondents experienced the cost growth and schedule growth of 0.13% and -0.15% respectively. The main reason for choosing the APD methods was schedule advantage followed by better quality, cost advantage, and fewer disputes. The higher number of respondents experienced time savings in comparison to cost savings through the use of innovation in their projects. Out of the total respondents, 91% will reuse APD methods again which is very encouraging findings for APD use in the future.

When the responses were subdivided into two groups based on types of respondents, PS are significantly more satisfied than UM with APD benefits related to quality, change order, and claims/disputes compared to DBB projects. Both UM and PS ranked schedule advantage, better quality, cost, and fewer disputes as the reasons of using APD methods. UM experienced schedule growth of 1.38% in their projects whereas PS experienced

schedule savings of 1.15% in their projects. This difference is significant at alpha level 0.05. However these two groups did not experience significant difference in cost savings.

When the data was subdivided according to types of project delivery experience, no significant difference between the satisfaction level of DB and CMAR project delivery users was detected. Regarding the ranking of the reasons for using APD methods, DB users ranked quality and cost as their second and third reasons of using APD methods respectively. However, CMAR users ranked exactly opposite to DB users. This difference in ranking is significant at alpha level 0.05. Both groups ranked schedule as first and fewer disputes as fourth reasons respectively.

The mean cost growth and schedule growth experienced by DB users were less than that experienced by CMAR users. This finding is similar to the findings made by Konchar and Sanvido (1998) in DB and CMAR building projects. The findings were significant in the Konchar and Sanvido study, but no significant difference was found in this study with water and wastewater project data. However, when the DB and CMAR users were asked about the cost savings in their projects, a significantly higher number of DB users responded that they saved cost compared to CMAR users.

The survey data showed that there is a difference in the cost and schedule performance of DB and CMAR water and wastewater projects. Therefore it is recommended conducting further study to determine the quantitative performance of DB and CMAR water and wastewater projects in order to verify that the DB project delivery method is superior to the CMAR project delivery method.

CHAPTER 4

CONCLUSION AND RECOMMENDATIONS

In the survey conducted, responses were received from the Utility Managers (UM), Project Staffs (PS), and Policy Makers who were involved in water and wastewater projects. From the responses received it was observed that the owners preferred the use of APD (DB, CMAR, and CM/GC) methods in water and wastewater projects due to advantages that the owner gets in schedule, followed by advantages in quality and cost. Most of UM and PS were satisfied with quality of completed projects, level of owner's involvement, communication among involved parties, innovative ideas used, generation of fewer claims/change orders, and smooth transition of constructed project to operation. Moreover, it was observed that two-step procurement process and a Best-Value Contractor-Selection method were preferred by the majority of respondents. Out of total respondents, 91% will use APD methods for their future projects.

PS were significantly more satisfied than UM with APD benefits related to quality, change order, and claims/disputes. PS experienced cost and schedule savings in their projects but UM had both cost and schedule growth. Konchar and Sanvido (1998) concluded that mean cost growth and schedule growth estimated by DB users were less than CMAR project delivery users in building and highway projects. These similar results were experienced by DB and CMAR project delivery users in water and wastewater projects in this survey.

Unfortunately, the lack of familiarity with the process, owners' sensitivity to risk, and resistance to change limited the use of APD methods. However, the use of APD methods in water and wastewater infrastructure will increase in future because of its advantages. However, studies have to be conducted; preferably detailed face-to-face interviews and project case studies in the future to ensure the owners' level of satisfaction of APD methods in water and wastewater projects.

APPENDIX: SURVEY QUESTIONAIRE

1. Respondents' General Information

1.1. Name/Title of the Respondent: (Optional) _____

1.2. Are you now, or have you been in the past 10 years, involved in Alternative Project Delivery of a water or wastewater project?

☐ Yes ☐ No

1.3. Project Location (City/State): _____

1.4. Type of Responsibility

☐ Policy Maker (Elected/Appointed Officials)

☐ Utility Managers

☐ Project Staffs

1.5. In which Alternative Project Delivery method do you have experience? (Check all that apply.)

☐ DB ☐ CMAR ☐ CM/GC

1.6. What type of Project was involved: (Check all that apply.)

☐ Wastewater Treatment Plant

☐ Water Treatment Plant

☐ Conveyance Project/Pumping Station

☐ Collection/Distribution System

☐ Storage Project

☐ Other type, please describe _____

1.7. How often have you been involved in projects built with Alternative Project Delivery methods?

☐ Only in one project ☐ Few projects (2-5) ☐ Many projects (> 5)

1.8. Choose the project characteristics and performance for the MOST RECENT projects you are/were involved in.

	Most Recent Project
Describe Solicitation Process	☐ One-step RFP ☐ Two-step (RFQ/RFP)
Describe Pricing Method	☐ Lump Sum – Firm fixed price at contract award ☐ Progressive Pricing – Fee/price set after phase 1 contract award
Describe Selection Criteria	☐ Price ☐ Best-Value ☐ Qualifications-only
Describe Capital Cost Range	☐ Less than $10M ☐ $10M to $100M ☐ More than $100M
Reason for using Alternative Delivery (Please click, drag, and drop each item into the position associated with the rank you wish to give the item relative to the others.) #1 is the "highest" and #5 is the "lowest":	☐ Cost Advantage ☐ Schedule Advantage ☐ Better Quality ☐ Few Disputes
	Other reasons: _____

(Do you want to provide information for more than the most recent project? If yes, then we will ask the above 1.7 question again)

2. Utility Managers/Project Staffs Questions

This section includes the questions related to level of satisfaction with your Alternative Project Delivery methods experience.

2.1. How satisfied are/were you with the overall project delivery experience? (Please move the bar to the desired level) ☐ Very satisfied ☐ Satisfied ☐ Neutral ☐ Unsatisfied ☐ Very unsatisfied

2.2. How satisfied are/were you with the quality of the completed project? (Please move the bar to the desired level)

☐ Very satisfied ☐ Satisfied ☐ Neutral ☐ Unsatisfied ☐ Very unsatisfied

2.3. How satisfied are/were you with the transition to operation? (Please move the bar to the desired level)

☐ Very satisfied ☐ Satisfied ☐ Neutral ☐ Unsatisfied ☐ Very unsatisfied

2.4. How appropriate was the risk distribution between Owner and Company in your project? (Please move the bar to the desired level)

☐ Very appropriate ☐ Appropriate ☐ Neutral ☐ Inappropriate ☐ Very inappropriate

2.5. How satisfied are/were you with the Company's communication process with Owner in the project you worked on? (Please move the bar to the desired level)

☐ Very satisfied ☐ Satisfied ☐ Neutral ☐ Unsatisfied ☐ Very unsatisfied

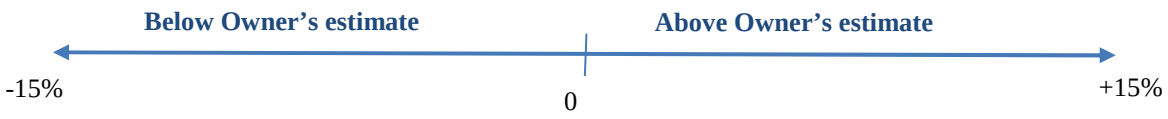
2.6. How satisfied are/were you with the level of Owner's involvement in the design process? (Please move the bar to the desired level)

☐ Very satisfied ☐ Satisfied ☐ Neutral ☐ Unsatisfied ☐ Very unsatisfied

2.7. What is your understanding of the level of satisfaction of other water infrastructure system Owners with the use of Alternative Project Delivery methods? (Please move the bar to the desired level)

☐ Very satisfied ☐ Satisfied ☐ Neutral ☐ Unsatisfied ☐ Very unsatisfied

2.8. Please estimate the difference between the final project cost and Owner's original estimate. (Please move the bar to the desired level)



2.9. Please estimate the difference between the final schedule and Owner's original schedule. (Please move the bar to the desired level)

2.10. Your project(s) that used Alternative Project Delivery methods has/have had significantly lower number of change orders than DBB projects. (Please move the bar to the desired level)

☐ Strongly agree ☐ Agree ☐ Neither agree nor disagree

☐ Disagree ☐ Strongly disagree

2.11. Your project(s) that used Alternative Project Delivery methods has/have had significantly lower claims and disputes than DBB projects. (Please move the bar to the desired level)

☐ Strongly agree ☐ Agree ☐ Neither agree nor disagree

☐ Disagree ☐ Strongly disagree

2.12. Are/were innovative ideas for the project(s) you worked on used to save money or time or to improve quality?

☐ Yes ☐ No

2.13. Do you believe that you saved money in using Alternative Project Delivery methods for your project?

☐ Yes ☐ No

2.14. Do you believe that you saved time in using Alternative Project Delivery methods for your project?

☐ Yes ☐ No

2.15. Would you use Alternative Project Delivery methods to build your projects again?

☐ Yes ☐ No

Please comment _____

3. Policy Maker (Elected/ Appointed) Officials Questions

3.1. What are the most important issues or impediments in obtaining public support and government body approval of Alternative Project Delivery methods? (Please click, drag, and drop each item into the position associated with the rank you wish to give the item relative to the others. #1 is the "highest" and #10 is the "lowest.")

☐ Perception of risk for owner

☐ Unfamiliarity with the process

☐ Resistance to change/ keep status quo

☐ Need to distribute projects among multiple (local) firms

☐ Existing statutory requirements

☐ Owner procurement rules

☐ Local/ small business preference

☐ Less control over the outcome by the owner staffs

☐ Would need more qualified personnel and resources during project procurement period

☐ Any other, please mention _____

3.2. How appropriate was the risk distribution between Owner and the Company in your project?

☐ Very appropriate ☐ Appropriate ☐ Neutral ☐ Inappropriate

☐ Very inappropriate

3.3. What is your understanding of the level of satisfaction of water infrastructure system Owners with the use of Alternative Project Delivery methods?

☐ Very satisfied ☐ Satisfied ☐ Neutral ☐ Unsatisfied ☐ Very unsatisfied

3.4. Would you support or advocate the use of Alternative Project Delivery for future water and wastewater infrastructure projects?

☐ Yes ☐ No

Comments _____

3.5. Do you believe that costs were less in using Alternative Project Delivery methods for your project?

☐ Yes ☐ No

3.6. Do you believe that time was saved in using Alternative Project Delivery methods for your project?

☐ Yes ☐ No

3.7. Would you support and advocate for the use of Alternative Project Delivery methods again?

☐ Yes ☐ No

Please comment

_____

4. Miscellaneous Questions

4.1. Would you like to have an electronic copy of this final survey report?

☐ Yes ☐ No

4.2. We will be conducting a follow up interview after this online survey. Are you interested to be contacted for this follow up interview?

☐ Yes ☐ No

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