PROJECT DELIVERY METHODS USED IN BUILDING CONSTRUCTION PROJECTS OF PAKISTAN

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Thesis of

Master of Science

by

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This is to certify that the

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Submitted by

Amna Shaukat

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2011

DEDICATED

TO

MY PARENTS, TEACHERS

AND

COLLEAGUES

ACKNOWLEDGEMENTS

I am thankful to ALMIGHTY ALLAH, who gave the opportunity and enabled me to complete my Master's Degree. I am extremely grateful to my parents for their sincere prayers and support during the entire length of my course and research work.

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ABSTRACT

In Pakistan, the traditional project delivery method used for building construction projects is “design-bid-build", especially in public sectors. Most of the projects following traditional project delivery method do not meet the desired project performance in terms of cost, time and quality. The projects performance can be improved by adopting non-traditional project delivery methods. This research study compares the cost and schedule performance of design-bid-build and design-build delivery method, using project data collected from 92 building construction projects of Pakistan. The results of the statistical analysis are presented in two major parts. First, the current procurement practices and delivery methods adopted in the selected construction projects are evaluated. Second, the performance of design-bid-build and design-build project delivery methods in terms of cost and schedule is compared. After statistical analysis of the collected data using SPSS, the results of the first part showed that the pre-qualification of contractor selection is being mostly used for the design-bid-build projects rather than design-build projects. Almost for the all design-bid-build projects contractors were selected through open competitive bidding, while for some design-build projects contractors were selected by negotiation. Single stage one envelope bidding procedure is the main open competitive bidding procedure used for most of the procurement. Single stage two envelope bidding procedure was used where the bids were to be evaluated on technical and financial grounds and price was taken into account after technical evaluation.

The trend of using PEC conditions of contracts was found less as compared to FIDIC because former were reported to be biased in favour of owners/clients. Incentive clauses were not included for 74% of the total projects due to the absence of these clauses in FIDIC/PEC Conditions of Contract Very few disputes were reported in both types of project delivery methods thereby signifying that the project delivery method has no effect on raising of disputes. Engineer’s decision and amicable settlement both were almost equally used for dispute settlement. Key findings of univariate analysis showed that unit cost of design-bid-build project was 22% more than that of design-build projects.

Very less significant differences were found in cost growth between design-bid-build and design-build project delivery methods. No significant difference was found from t-test analysis in unit cost, cost growth and construction speed between the two project delivery methods except schedule growth metric. This difference is more likely due to the fact that design build projects were executed by fast tracking and single point responsibility. Also, results indicated that the design-build projects had large construction speed, therefore, resulted in better schedule performance. It is concluded that the projects performance can be greatly improved by adoption of non-traditional project delivery methods. The present study was restricted to univariate analysis only. It is recommended that future studies may be carried out which include multivariate analysis.

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Chapter-1

INTRODUCTION

1.1 GENERAL

The construction industry attracts a wide variety of clients all of whom have their own objectives and priorities for their particular project. Consequently when a client is making the decision to build, a number of important decisions need to be made in order for the project to have a good chance of a successful outcome in terms of cost, schedule and quality (Cooke and Williams 2009).

Obtaining a project within a predefined time, cost and quality is the ultimate goal of the clients. Though projects have become more complex and quality standards have increased, much less time and cost have been allocated in the designing, bidding, planning and construction of the building projects. Also the need for more financial planning and fewer amounts of contract has increased the possibility of looking out for new construction procurement methods. Insufficient attention has been given to how clients will systematically incorporate the new procurement methods not only to their own advantage but to attract the energy of private procedures (Miller and Evje 1999)

Uher and Davenport (2002) suggests that apart from examining the issues of management, design and construction, reaching an appropriate contract strategy requires careful consideration of:

- the choice of a project delivery method
- the choice of a contract price
- how the contractor should be selected
- the choice of conditions of contract
- the allocation of risk to the parties through the contract documents

Project delivery methods are specifically designed organization structures for delivering construction projects within cost and time budgets. They define contractual links among the key project team members and the flow of information within the hierarchical management structure (Figure 1.1). Methods vary and their nature is determined by the roles played by the project team members, the relationships

between them, the timing of events, as well as the formal general conditions of contract used (Uher and Davenport 2002).

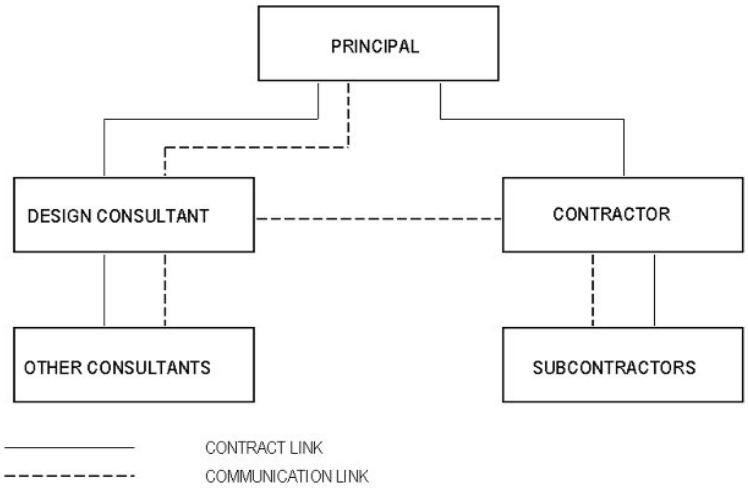

Figure 1.1: A project organisation structure

Source: Adapted from (Uher and Davenport 2002)

There are several project delivery methods available for the owners to deliver construction projects within allocated cost and time. These methods give the client a choice of various management structure, different contractual arrangements and varying degrees of client risk (Griffiths et al. 2006).

Since the late 1960s, research studies have been attempting to assess the performance of the traditional method of project delivery in comparison to non-traditional methods. In recent years, more studies have confirmed that large and complex projects with a higher element of risk achieve better outcomes under non-traditional methods of delivery (Naoum and Langford 1990).

Management contract outperformed as compared with the traditional contract in respect of several factors such as the issue of time, advice from contractor on buildability, and flexibility during construction, allowing the greater variation without affecting project performance (Naoum 1994). Corrective actions have been taken to adopt the delivery systems (Design-Build, Construction Management at-Risk, Design-Build-Operate, Job Order Contracting) in attempts to allocate risk to the party most capable of minimizing the risk. While these processes have produced some encouraging results (Pocock 1996), they have not significantly impacted the quality of construction crafts people (Garrity and Kathleen 1999).

Pocock et al. (1996) in their study verified the relationship between project's degree of interaction and performance indicators such as cost growth and schedule growth. Songer and Molenaar (1996) conducted a research to address owner's attitude towards project delivery method and pointed out the rapid growth of design-build project delivery method.

Konchar and Sanvido (1998) conducted a study whose goal was to compare the different delivery systems that are widely used in the United States. Construction management at risk, design-build, and design-bid-build were the three main delivery approaches compared. The median scores reported through the results of the research concluded that projects delivered using the design-build approach performed better than those delivered through the construction management at risk or the design-bid-build delivery systems regarding several performance metrics.

El Wardani et al. (2004) in their research quantitatively analyzed the correlation between the design-build procurement method and the performance of the design-build with regard to cost, time, and quality metrics. Although limited in numbers, the research consistently pointed out the low performance of project carried out under traditional project delivery method. Probably, no such study has been carried out which compare the cost and schedule performance of design-bid-build and design-build delivery method for building construction projects within Pakistan.

1.2 PROBLEM STATEMENT

In Pakistan, the traditional project delivery method used for building construction projects is "design-bid-build", especially in public sectors. Most of the projects following traditional project delivery method do not probably meet the desired project performance in terms of cost, time and quality. The projects performance can be improved by adopting non-traditional project delivery methods (Design-Build, Construction Management at-Risk, etc.). Keeping in view of above, the present study was carried out to evaluate the performance of project delivery methods being used in building construction projects of Pakistan.

1.3 OBJECTIVES

The main objectives of the present study are;

1. To examine the current procurement practices and delivery methods adopted in the selected construction projects.

2. To compare the performance of design-bid-build and design build project delivery methods in terms of cost and schedule.

3. To suggest measures for adoption of non-traditional project delivery methods in construction industry of Pakistan.

1.4 SCOPE AND LIMITATIONS OF RESEARCH

The scope of the present research was to empirically compare cost and schedule performance of projects delivered using design-bid-build and design-build delivery methods in Pakistan. Initially it was planned to compare cost and schedule performance of projects by univariate comparison and multivariate linear regression. But now it has been confined to univariate comparison of cost and schedule performance metrics between design-bid-build and design-build delivery methods due to shortage of time and unavailability of sufficient data to develop regression models.

1.5 ORGANIZATION OF THESIS

Chapter 1 provided an overview of this research study. Chapter 2 presents literature review on project delivery methods, construction contracts and bid procurement methods. Chapter 3 describes methodology used in the research to achieve the study objectives and chapter 4 covers test results and discussions. Chapter 5 summarizes results of the main findings, acknowledges the limitations of this research and provides an out line for future research.

Chapter-2

LITERATURE REVIEW

2.1 PROJECT DELIVERY METHOD

Project delivery methods are specifically designed organization structures for delivering construction projects within cost and time budgets. They define contractual links among the key project team members and the flow of information within the hierarchical management structure. Methods vary and their nature is determined by the roles played by the project team members, the relationships between them, the timing of events, as well as the formal general conditions of contract used (Uher and Davenport 2002).

The major two types of project delivery methods are:

i. Traditional (Design-Bid-Build)

ii. Non-traditional (Design-Build, Built Operate& Transfer, etc) as shown in Figure 2.1.

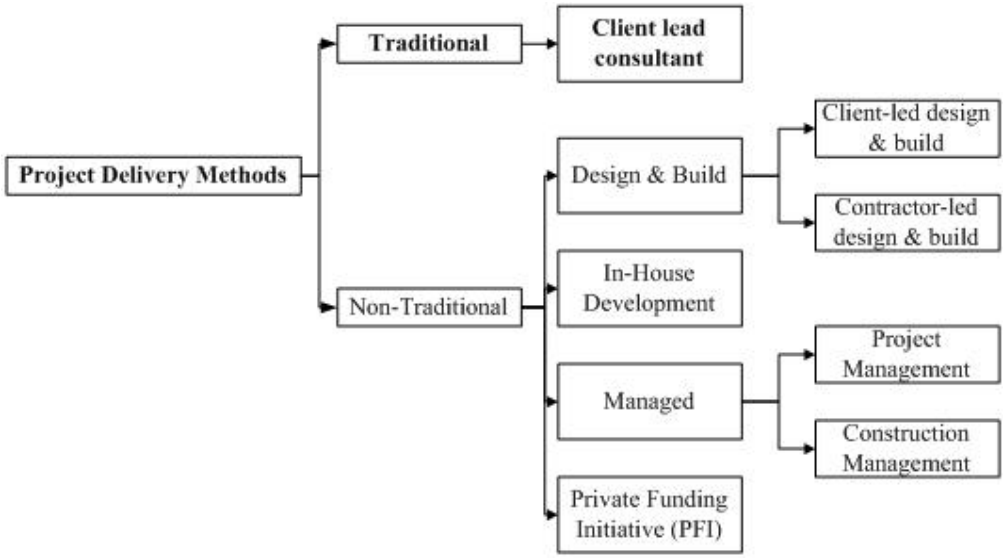

Figure 2.1: Project Delivery Methods

Source: Adapted from (Uher and Davenport 2002)

2.1.1 Traditional Project Delivery Method

The traditional (Design-Bid-Build) method of project delivery is based on the rigid separation of design and construction. The client appoints a team of consultants (led by the architect/engineer) to undertake the detail design. The design team prepares detail drawings, specifications and often a Bill of Quantities (BOQ). The tender documents are prepared and the contract awarded by the client, usually to the contractor with the lowest bid (Potts 2008).

The principal (Owner/Client), the design consultant and the contractor are the three main parties that form the structure of the traditional delivery method as shown in Figure 2.2. The principal selects the main design consultant to design and document the project. Using a competitive tender process, the principal then selects a contractor and enters into a formal contract (the main contract) with that contractor to build the facility as designed. The contract price paid to the contractor may be in the form of a lump sum, a schedule of prices, unit rate, etc. (Uher and Davenport 2002)

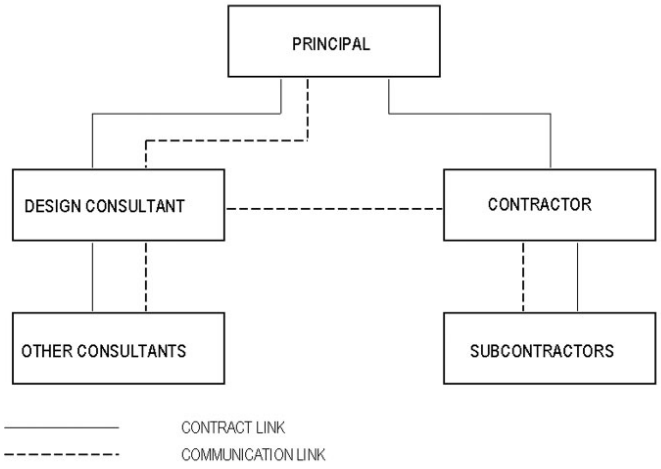

Figure 2.2: The traditional method of project delivery

Source: Adapted from (Uher and Davenport 2002)

2.1.2 Non-traditional Project Delivery Method

The 'non-traditional method' means a method of project delivery that is different from the traditional method. It implies a departure from the 'traditional' triangular contractual relationship involving the principal, design consultant and the contractor in favour of more effective management of each of the individual stages of

the project lifecycle and the project as a whole. An important characteristic of non-traditional delivery methods is their reliance on fast-tracking, which means overlapping of the design and construction stages to speed up a project (Uher and Davenport 2002).

Uher and Davenport (2002), grouped non-traditional project delivery methods as:

- design and build method
- managed methods, namely construction management and project management
- In-house development method
- Concessional or PFI (private funding initiatives) methods.

However, in this research study the scope is restricted to investigate design-build project delivery method only.

2.1.3 Design-Build Method

According to Cooke and Williams (2009), there are several varieties of design and build, the basic idea is that there is a single point of responsibility for both the design and construction of the project. The principal forms a contract with the contractor to design and construct the facility as shown in Figure 2.3. The principal intends the contractor to be a single-point responsibility for delivering the project (Uher and Davenport 2002).

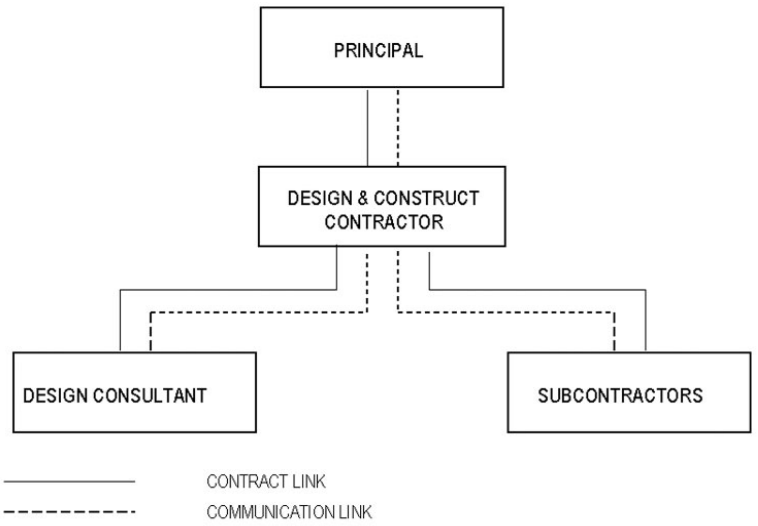

Figure 2.3: The design and build method of project delivery

Source: Adapted from (Uher and Davenport 2002)

Cooke and Williams (2009) identified two extreme conditions in relation to design-build, Extreme A and Extreme Z. A brief explanation of the two extremes and other design-build variants is given in the section below.

2.1.3.1 Extreme A – client-led design and build

With Extreme A, the client can be fully involved in influencing the design development. Prior to tender action, it may be that the design will be virtually complete possibly with full bill of quantities. There may also be prescriptive specifications for specialist installation such as heating, ventilating and air conditioning. At this stage, a small number of contractors will be invited to tender for the project. Here, the design risk is fully by the client because tenderers will have little to add to the fundamental design. This method is referred to as develop and construct because the contractor inherits **the design and develops** the detail required for production stage of the project. According to Gidado and Arshi (2004), It is a hybrid of D&B in which the contractor inherits the design that might have been produced by client's consultants up to Stage D (Detail proposal) on the RIBA Architect's Appointment Scale. This is developed further by the contractor in terms of detailing taking into account the construction technique to be adopted for the project. Develop and construct organizational arrangement differs from traditional design-build only in the extent to which the owner develops design before engaging the construction contractor. Projects vary from owners who have only outline specifications to those having detailed requirements. The owner would then utilize an in-house design staff or appoint a design consultant to further develop these varying levels of design (Sanvido and Konchar 1998).

An alternative twist on develop and construct, which is popular with many clients, is to novate the architect or design team to contractor once the contract have been awarded. This variant is known as **novation design and build** because the client's architect, or may be other members of design team, are legally passed over to the contractor in order to produce the detailed aspects of the design. The novation arrangement should be agreed with the architect when he/she is first appointed (Cooke and Williams 2009). The client passes his architect to contractor to produce detailed drawings as part of the contractor's team. During the design stage through to the appointment of the D & B contractor, the architect works directly for and is paid by the client. Once a contractor has been appointed the architect's appointment is

assigned to the contractor for whom the architect produces any outstanding information, which is necessary to construct the work. In some cases, once the practical completion of the work has been reached, the architect reverts back to be employed by the client. Beyond this stage, he/she is to prepare the list of defective and outstanding items, monitor the completion of the same and certify the completion of the project at the end of the defects liability period (Gidado and Arshi 2004). Consultant novation arrangements are used for approximately 50 percent of all new design-build work in the UK. In this arrangement owner seeks independent design advice during the briefing stage from one or more design consultants. Design consultants advance design to a stage when a contractor is engaged into the process. From this point forward the consultants employment is "novated" or assigned to the contractor, thus shifting design and construction risk to the selected contractor for the remainder of the project (Sanvido and Konchar 1998).

2.1.3.2 Extreme Z – contractor-led design and build

In Extreme Z, the client may wish to provide the contractor with minimal information in the form of an outline brief (RIBA Stage B – Strategic Briefing). This will leave design and build contractor fully responsible for the conceptual and detailed design in order to meet the employer's requirements. The contractor will then submit a bid on the basis of Contractor's Proposals. Full design responsibility will be taken by the contractor to produce a building in respect of the client's time, quality and cost requirements. This variant is known as **traditional design and build**. The contractor may provide an in-house design facility or independent design teams may be used. With a team arrangement, it is normal for the design and build contractor to employ a design team coordinator as a key member of the team to ensure the flow of information between the design team and the project team in order that key design and constructor dates are adhered to (Cooke and Williams 2009). The contractor accepts the total responsibility for both the design and construction to meet the requirement of the client (Gidado and Arshi 2004).

2.1.3.3 Other design and build options (somewhere between extremes A and Z)

It is most probable when using design and build procurement procedures will fall somewhere between the two extremes described above. Definitions of alternative arrangements are outlined by Janssens (1991), Masterman (2002) and Morledge et al.

(2006) and these indicate the wide range of options available. Following are the other design and build options;

- Package deal (including turnkey contracts): The contractor provides standard buildings or system buildings that are adapted to suit clients' space and functional requirements (Gidado and Arshi 2004).
- Design and manage: The contractor gets a fee for managing all aspects of planning and design and supervising the subcontractors. The contractor has design responsibility (Gidado and Arshi 2004).
- Design, manage and construct. This is similar to 'design and manage' except that the contractor is involved in construction of some work sections in addition to coordinating the activities of the subcontractors on site (Gidado and Arshi 2004).

2.2 TYPES OF CONSTRUCTION CONTRACT

There are several methods for pricing construction contracts. The project owner selects the method for a particular project based on risk associated with the project, deciding how much risk to assume and how much to impose on the construction contractors. The amount of risk borne by the contractor varies depending on the pricing method selected by the client (Holm et al. 2005). The decision made on the most appropriate option of project delivery will be closely followed by a decision on the most appropriate option for the contract price (Uher and Davenport 2002).

2.2.1 Lump Sum Contract

A lump-sum contract is the simplest form of contract. It fixes the price to be paid for carrying out the work, before the start of the contract. A lump-sum price should cover all costs, overheads, risk contingencies and profit (Uher and Davenport 2002). According to Holm et al. (2005), these contracts are used when the scope of work can be defined. The owner provides a set of drawings and specifications and the contractor agrees to complete the project for a lump sum. Lump-sum contracts are also used for design-build projects where the owner specifies design criteria, and the contractor agrees to design and construct the project for a single price. While the exact scope of work is not defined in a design-build project, the contractor controls

the design process and produces a design that can be constructed within the contract price.

2.2.2 Unit Price Contract

A Unit price contract is used when the exact quantities of work are not known at the time the contract is signed. The designer provides an estimate of the material quantity of each element to be constructed, and the contractor determines the unit price for each element. The actual contract value is not determined until the project is completed. The actual quantities of work are measured during the completion of the project, and the cost is determined by multiplying the actual material quantity by the unit price established by the contractor (Uher and Davenport 2002).

2.2.3 Schedule Price Contract

When the extent of the work (particularly quantities) is unknown even though full documentation is available, the contractor will often tender for the work using a schedule of prices/rates. The terms 'schedule of rates' and 'schedule of prices' are used by different people to describe what are essentially the same schedule. In Australia, a schedule of prices or a schedule of rates may include estimated quantities of the work to be performed. A schedule of prices is sometimes in the form of a priced bill of quantities. The main limitation of schedule contracts is that the total cost of a project is unknown until the work is completed. Since the total project cost is calculated by applying schedule prices to the quantity of the work executed, regular auditing of the contractor's claims for payment is necessary for effective cost control. In public sector engineering, schedule of rates contracts are used almost exclusively. It is common to provide a schedule setting out not only the items for which a rate is required but also estimates of quantities. Such a schedule is more accurately described as a 'schedule of estimated quantities and rates' but it is more commonly described simply as a schedule of rates. In order to reduce the risk for both contractual parties, some standard conditions of contract stipulate agreed limits of accuracy for estimated quantities (Uher and Davenport 2002).

2.3 PRE-QUALIFICATION OF CONCTRACTORS

A procuring agency, prior to the floating of tenders, invitation to proposals or offers in procurement proceedings, may engage in pre-qualification of bidders in case of services, civil works, turnkey projects and in case of procurement of expensive and technically complex equipment to ensure that only technically and financially capable firms having adequate managerial capability are invited to submit bids. Such pre-qualification shall solely be based upon the ability of the interested parties to perform that particular work satisfactorily (Public Procurement Rules 2004). The owners may require prospective contractors to submit documentation of their qualifications for review before being allowed to submit a bid or proposal, or the owners may open the solicitations to all qualified contractors. Requiring contractors to submit their qualifications prior to being allowed to submit a bid or proposal is known as prequalification of contractors (Holm et al. 2005).

2.4 PPROCUREMENT METHODS

A construction contract between the principal and the contractor can be formed in several different ways, for example by negotiation, by competitive tendering (Uher and Davenport 2002). Owners use either a bid or a negotiated procurement process to select a construction contractor for a project. Public owners, such as government agencies, use public solicitation or procurement methods. Private owners can use any method they wish to select contractors, but most use contractors with whom they have had a good experience in the past. Private owners might ask only a select few or even one contractor to submit a bid or proposal (Holm et al. 2005). Public procurement in Pakistan is regulated by the Public Procurement Regulatory Authority (PPRA), which has notified the Public Procurement Rules 2004 (PPR 2004).

2.4.1 Open Competitive Bidding

Under Public Procurement Rules (2004) it is stated that the procuring agencies shall use open competitive bidding as the principal method of procurement for the procurement of goods, services and works.

2.4.1.1 Procedures of open competitive bidding

According to the Public Procurement Rules (2004), the following procedures of open competitive bidding shall be selected in the following circumstances, namely:-

a) Single stage one envelope bidding procedure shall ordinarily be the main open competitive bidding procedure used for most of the procurement.
b) Single stage two envelope bidding procedure shall be used where the bids are to be evaluated on technical and financial grounds and price is taken into account after technical evaluation.
c) Two stage bidding procedure shall be adopted in large and complex contracts where technically unequal proposals are likely to be encountered or where the procuring agency is aware of its options in the market but, for a given set of performance requirements, there are two or more equally acceptable technical solutions available to the procuring agency.
d) Two stage two envelope bidding method shall be used for procurement where alternative technical proposals are possible, such as certain type of machinery or equipment or manufacturing plant.

2.4.2 Negotiated Contract

Negotiated contracts are formed by direct negotiation between the principal and the contractor. This procedure may be applied in those circumstances when the work is so urgent that there is no time for inviting tenders, or when the principal believes that only one particular contractor is capable of building a project, or when spending time and money on tendering would be wasteful. Negotiated contracts are more common in the private sector than the public sector (Uher and Davenport 2002). Most negotiated contracts are awarded using the two-step process. First, prospective contractors are invited to submit their qualifications for the project. After review of their prior work experiences and safety records, the most qualified contractors (usually four to six) are short listed. Second, short listed contractors are invited to submit proposals containing specific project information requested by the owner. Since the contractors may suggest design modifications in their proposals, the owner usually discusses each proposal with the contractor who submitted it. Based on this discussion, the owner may issue an addendum, clarifying any issues and then ask each

proposer to submit a best and final proposal. As a part of the evaluation process, owners may require each contractor to make a presentation explaining its plans for managing the project. The owner then selects the contractor submitting the proposal that is ranked highest based on the owner's evaluation criteria and negotiates a contract price, and maybe a project duration. The pre-proposal conference is similar to the pre-bid conference used in the bid method. Once the negotiations are completed, the owner may or may not require the successful proposer to submit performance and payment bonds before awarding the construction contract (Holm et al. 2005).

2.5 AWARD OF PROCUREMENT CONTRACT

The bidder with the lowest evaluated bid, if not in conflict with any other law, rules, regulations or policy of the Federal Government, shall be awarded the procurement contract, within the original or extended period of bid validity (PPR 2004).

2.6 RELATED STUDIES

Naoum (1994) in his research identified ten factors to measure project performance: (1) Preconstruction time; (2) construction time; (3) total time; (4) speed of construction; (5) unit cost of building; (6) time overrun; (7) cost overrun; and client satisfaction with (8) time, (9) cost, and (10) quality. He used a theoretical framework to compare project performance in a case study sample of 39 management contracts and 30 traditional contracts. His study suggested that management contracting performs significantly better in some respects than traditional contracting, in particular, when time was the essence of the contract and when the project was highly complex. However, his research did not provide enough evidence to support the view that management contracting can reduce the overall building cost, or that the system can increase the standard of quality. It was concluded that in neither the management nor the traditional system lies the solution to all the problems facing the construction industry.

Pocock et al. (1996, 1997) in their study developed a method to measure the degree of interaction (DOI) and its impact on project performance, such as cost growth, schedule growth, and number of modifications, using traditional and alternative project approaches. In their study they concluded that projects executed

with alternative approaches have significantly higher average degree of interaction than do traditional projects, indicating that they provide better opportunities for interaction

Songer and Molenaar (1996) conducted a research to address public and private owner's design-build selection attitude. Primary design-build selection factors identified and analysed included establishing cost, reducing cost, establishing schedule, shortening duration, reducing claims, large project size/complexity, and constructability/innovation. This research concluded that owners feel very strongly that design-build should be selected to shorten duration, but for specific projects the motivation for choosing it may be to establish cost, to reduce claims and any of the others. Also, private and public sector owner attitudes are consistent when selecting design-build project delivery method.

Sanvido and Konchar (1998) conducted a research study that empirically compared the cost, schedule, and quality performance of U.S. building projects that used construction management at risk, design-build, and design-bid-build project delivery systems. A comprehensive data collection instrument including quantitative cost, schedule, and quality performance data was used to collect data for 351 U.S. building projects. The data collection instrument (i.e., structured survey) examined the three principal project delivery systems, considered seven different contract types, and collected project data for the seven critical performance metrics. The instrument also collected information on 19 characteristics of the project team and its environment, nine classes of major building systems, the success criteria for the project, and lessons learned from the project. Several techniques were used to verify, check and analyse collected data. To standardize data across the entire sample, the costs for each project were adjusted using historical cost indices. Indexing was necessary to compare projects built in different locations during different years. The univariate analysis was performed first to compare the results of performance metrics such as cost, schedule and quality between project delivery system. The median scores reported through the results of the research concluded that projects delivered using the design-build approach performed better than those delivered through the construction management at risk or the design-bid-build delivery systems regarding several performance metrics. Multivariate linear regression models were built for cost and schedule metrics

using nearly 100 explanatory and interacting variables. Unit cost, construction speed and delivery speed represented primary results or areas of greatest certainty. Cost and schedule growth models represented areas of less certainty. This analysis identified several variables that consistently affected project performance. Delivery system and facility type were each among the list of variables that explained the greatest proportion of variation within performance models.

A comprehensive analysis of 67 global projects from the Construction Industry Institute's database showed that design-build projects may not provide all the benefits to project performance. The study found timesaving was a definitive advantage of design/build project delivery, but, the positive effects of cost and productivity changes were not convincing. Based on the results of the study, the project management expertise and experience of the contractor may have a greater impact on project performance outcomes than focusing on project delivery strategy only (Ibbs et al. 2003).

El Wardani et al. (2004) in their research quantitatively analyzed the correlation between the design-build procurement method and the performance of the design-build project with regard to cost, time, and quality metrics. The procurement methods studied were sole source, qualifications-based, best value, and low bid selection. Data were collected through surveys from 76 design-build projects in the United States. Based on the patterns and relationships identified from these data; a better understanding of the procurement process and how it influences project performance were achieved. The impact of project-specific factors and guidelines were presented to assist owners in selecting the design-build team procurement method that responds to their project goals.

As no study has been carried out to evaluate the performance of project delivery method being used in the building construction projects in Pakistan, the present research study is the first study to carry out such an evaluation of project delivery methods.

Chapter-3

METHODOLOGY

3.1 GENERAL

The plan of the present study was to empirically compare cost and schedule performance of projects delivered using design-bid-build and design-build delivery methods. Research methodology of the present study was based on a research report of the Construction Industry Institute (CII) (Konchar and Sanvido 1998). The research has been done on the steps shown in the Figure 3.1.

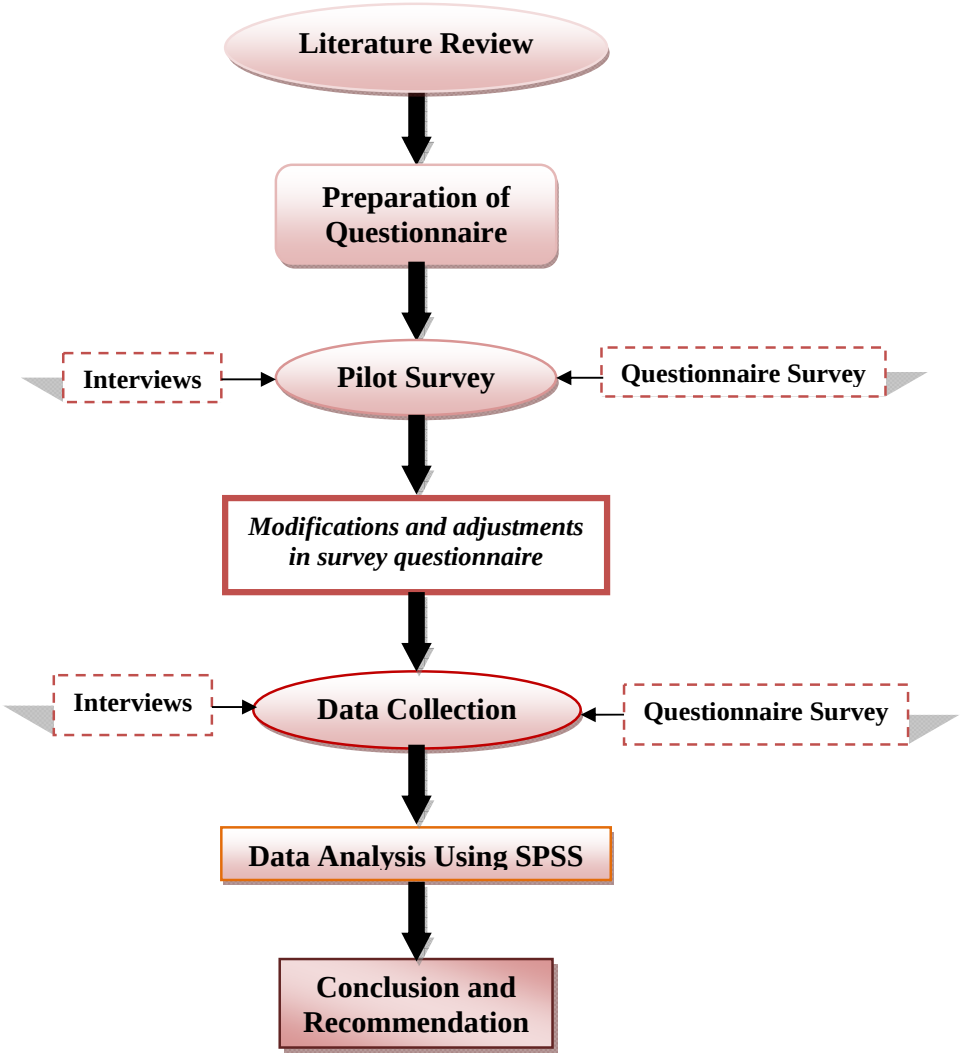

Figure 3.1: Research methodology flow chart

3.2 DEVELOPMENT OF QUESTIONNAIRE

Survey questionnaire of the same study was modified and adjusted after carrying out a pilot survey. The developed final questionnaire consists of ten sections (Appendix-I). The first section is regarding the general information about the respondents. The second section describes the project characteristics. It includes project name, year of completion, project location, name of client and project nature. Physical characteristics such as project gross covered area and number of floors were also documented. In the third section the respondents were asked to select the project delivery method used on their projects according to provided definitions of design-bid-build and design-build. Section IV is regarding the information about the selection of contractor and procurement method. Then in Section V, the respondents were asked about the construction contract type selected for the payments of projects. Sections VI and VII are the most important sections of the questionnaire. Section VI collects the data regarding the projects which includes the contract award cost and final project cost to build the facility. Contract costs represent the amounts agreed upon at the time the contract was signed. Final cost includes changes and modifications to the contract. Schedule information is collected in Section VII by asking respondents for information such as; as built construction start date, proposed completion date and as built construction end date of the project. Respondents were also asked to state the percentage of design complete when the construction entity joined the project team. The next Section asks for the number of projects involving disputes and the mechanism used to resolve them. Section IX is related to the type of conditions of contract used, incentive clauses, liquidated damages clause and escalation clause. In the last section respondents are requested to share their experience which they had during the lifecycle of project and lessons thus learnt from the project.

3.3 STUDY RESPONSE RATE

Response rate is the ratio of survey respondents who actively participated in the survey to the number of respondents actually reached through the survey (Konchar and Sanvido 1998). Total 115 questionnaires were distributed out of which 92 (80 percent) valid responses and 7 (6 percent) invalid responses were received. There was no response for 16 questionnaires as shown in Figure 3.2.

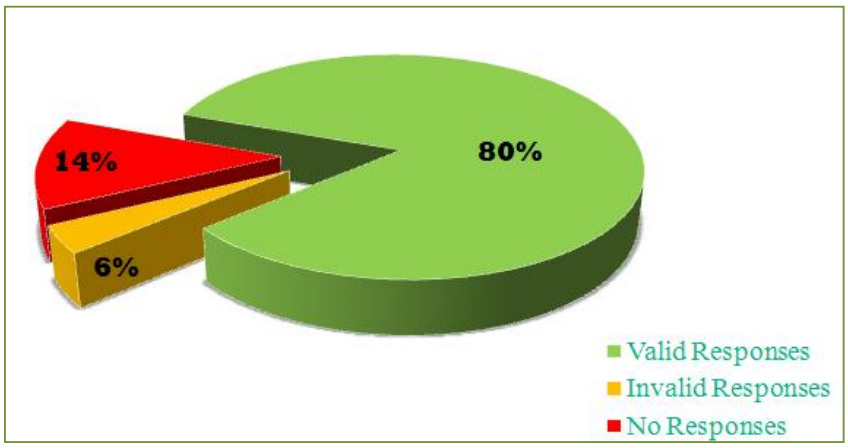

Figure 3.2: Study response rate

The area wise distribution is revealed in Figure 3.3. 42 (Rawalpindi / Islamabad), 30 (Lahore Region), 5 (Faisalabad), 1 (Multan), 2 (Karachi), 10 (Various District of Azad Jammu Kashmir), 1 (Gujrat), 1 (Kallar Kahar).

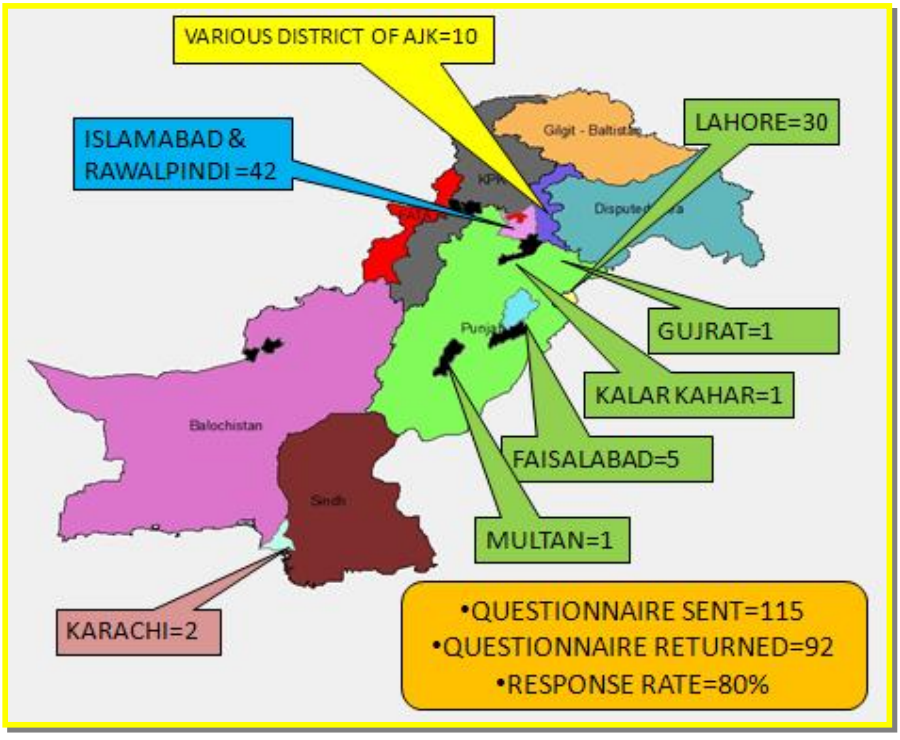

Figure 3.3: Area wise response rate

3.4 DEFINITION OF COST AND SCHEDULE PERFORMANCE MEASURES

Cost and schedule performance metrics were used to compare the performance of project delivery methods. These were dependent variables and calculated after project completion. The following sections define each performance metric.

3.4.1 Cost Measures

The first metric "unit cost" was defined as the total cost of the project divided by its area. It was calculated by the formula:

Unit cost (Rs in million/ft²) = Final Project Cost/Area (3.1)

A cost index was used to make accurate comparisons of projects built in different years. The data for unit cost was adjusted by using Wholesale Price Index, Federal Bureau of Statistics (2010).

The second metric "cost growth" was defined as the difference between final completion cost of the project and the contract cost calculated by:

*Cost Growth (%) = [(Final Project Cost- Contract Award Cost) / Contract Award Cost)]*100* (3.2)

3.4.2 Schedule Measures

Schedule metrics defines the time taken by the facility team and the owner to deliver the facility (Sanvido and Konchar 1998). Schedule measures include schedule growth and construction speed.

Schedule growth, third metric, was defined as the difference between the total time used to complete the project and the planned/estimated time to complete the project calculated by:

*Schedule Growth (%) = [(Total as Built Construction Time-Total as Planned Construction Time)/ Total as Planned Construction Time)]*100* (3.3)

Construction speed was defined as the facility gross square foot area divided by the as built construction time. It was calculated by:

Construction speed (ft²/month) = Area/ Total as Built Construction Time (3.4)

3.5 DATA ADJUSTMENT

3.5.1 Cost Indexing

Cost indices are used to predict the cost of the project based on the cost of a similar project at another location and/or constructed in different time frame (Holm et al. 2005). Wholesale Price Index (WPI) is designed for those items which are mostly consumable in daily life on the primary and secondary level; these prices are collected from wholesale markets and also from mills at organized wholesale market level. The WPI covers the wholesale price of 106 commodities prevailing in 18 major cities of Pakistan. Through its own staff and voluntary co-operation of government departments, autonomous bodies and private agencies FBS receives the wholesale prices from various areas in Pakistan. The prices are usually reported on monthly basis. WPI covers 425 items, divided in five major commodity groups viz (i) Food, (ii) Raw material, (iii) Fuel, Lighting and Lubricants, (iv) Manufacturing, (v) Building material. So, for many of the commodities more than one specification and markets have been used to have average prices (Federal Bureau of Statistics 2010). In this research study the unit cost metric is standardized because their calculation involves the costs of projects completed in different years by using WPI (Table. 3.1).

Table 3.1: WPI on Yearly basis

Period	Index	Period	Index
2005-06	136.68	2008-09	201.10
2006-07	146.18	2009-10	226.49
2007-08	170.15	2010-11 (JUL-DEC)	262.94

All data costs were converted to year 2010. As the actual 2011 index was not yet published, therefore, the twenty one building projects constructed till March, 2011 were considered as completed in December 2010 for time correction purposes. The formula used for time adjustment using the historical cost indexes is:

Cost (current year) = Cost (base year) x WPI (current year)/ WPI (base year) (3.5)

In the case of converting the cost to 2010, the formula is equal to:

Cost (2010) = Cost (2009) x WPI (262.9)/ WPI (201.1) (3.6)

3.6 DATA ANALYSIS TECHNIQUE

Statistical Package for Social Sciences (SPSS-18) was used to analyze collected data. Following statistical techniques were used to analyze the data:-

3.6.1 Univariate Analysis

The analysis commonly involves reporting measures of central tendency (mean, median) and also, involves studying the statistical dispersion (range, interquartile range and the standard deviation).

3.6.2 Test for Normality

An evaluation of the normality of data is a requirement for many statistical tests as normal data is an underlying assumption in parametric testing. Normality is assessed either by graphically or numerically. The Kolmogorov-Smirnov Test and the Shapiro-Wilk Test have been used in this study to check the normal distribution of data. For the normality test, the hypotheses are:

Null Hypothesis (Ho): data follow a normal distribution
Alternative Hypothesis (Ha): data do not follow a normal distribution

The p-values obtained from the Shapiro-Wilk Test are tested against the significance level, $\alpha = 0.05$. In case, if p-value is less than level of significance ($\alpha = 0.05$) then it would result in the rejection of null hypothesis and data will not be considered normally distributed. Otherwise, it will be considered normal.

3.6.3 Independent t-test

The independent t-test is an inferential statistical test that determines whether there is a statistically significant difference between the means of two groups (Chaudhry and Kamal 2008). For the independent t- test, the hypotheses are:

Null Hypothesis (Ho): the population means are equal, i.e. $\mu 1 = \mu 2$
Alternative Hypothesis (Ha): the population means are not equal, i.e. $\mu 1 \neq \mu 2$

Significance level at $\alpha = 0.05$ have been used in this study to accept or reject the alternative hypothesis.

Assumptions in using independent t-test are:

a. The dependent variable is approximately normally distributed within each group.
b. The variances of the two groups are equal.

3.7 DATA RECORDING AND ANALYSIS PROCEDURE

- Total 92 building projects were selected for the present study. Data of all collected projects were entered in MS-Excel sheet with project name, type of project, year of completion, contract type and owner type using numerical coding. Data such as project gross covered area, contract cost, completion cost, project anticipated and actual duration were entered without coding (Appendix-II & III).
- Project data entered in MS-Excel sheet was imported in Statistical Package for the Social Sciences (SPSS) for analysis.
- Projects that did not meet the scope of study in terms of completion time and project nature were eliminated from the analysis.
- Using descriptive statistics tests, the mean values for all the cost and schedule performance metrics were compared after replacing outliers with appropriate valid values.
- Box plots were also plotted to compare project delivery systems graphically.
- The Independent t-test conducted to determine whether there is a statistically significant difference between the means of two project delivery methods.
- Normal distribution and equal variance assumption were checked, at 95% confidence level, to determine the validity of the data collected for Independent t-test.

Chapter-4

RESULTS AND DISCUSSIONS

4.1 DATA SETS

Of the 92 projects data collected, 50% of the total number of projects was delivered by design-bid-build and 50% were design-build. The distribution of the projects according to the year of project completion is shown in Table 4.1.

Table 4.1: Project distribution by year of project completion

Year of Completion	Frequency	Percent	Valid Percent	Cumulative Percent
2011	21	22.8	22.8	22.8
2010	36	39.1	39.1	62.0
2009	10	10.9	10.9	72.8
2008	14	15.2	15.2	88.0
2007	7	7.6	7.6	95.7
2006	4	4.3	4.3	100.0
Total	92	100.0	100.0	

These projects were constructed from January, 2006 to March, 2011. However, it can be observed that the majority of the projects were completed between 2010 and 2011 (Figure 4.1).

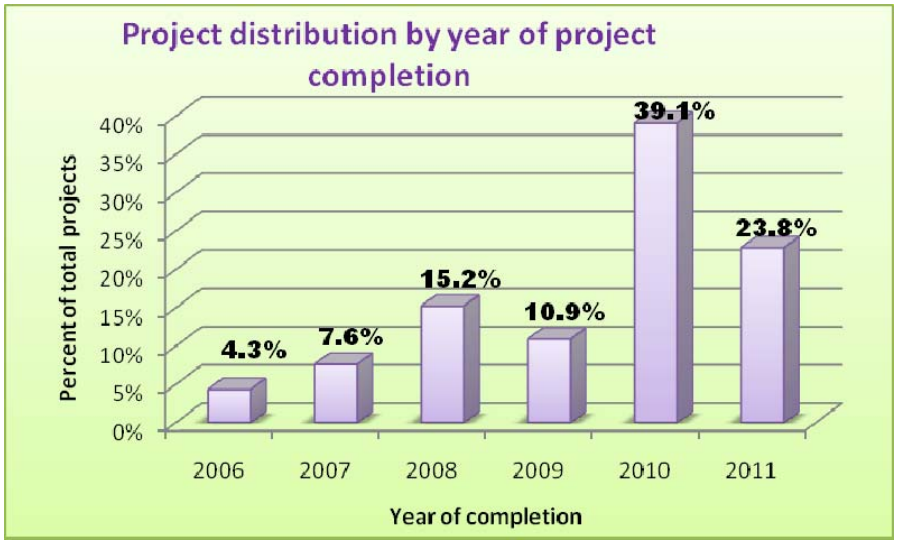

Figure 4.1: Project distribution by year of project completion

The distribution of facility area is shown in Figure 4.2. Projects ranged in size from 2000 square feet to over three million square feet. Figure 4.2 charts seven intervals of project size. Each interval represents 100,000 square feet except the first and last interval.

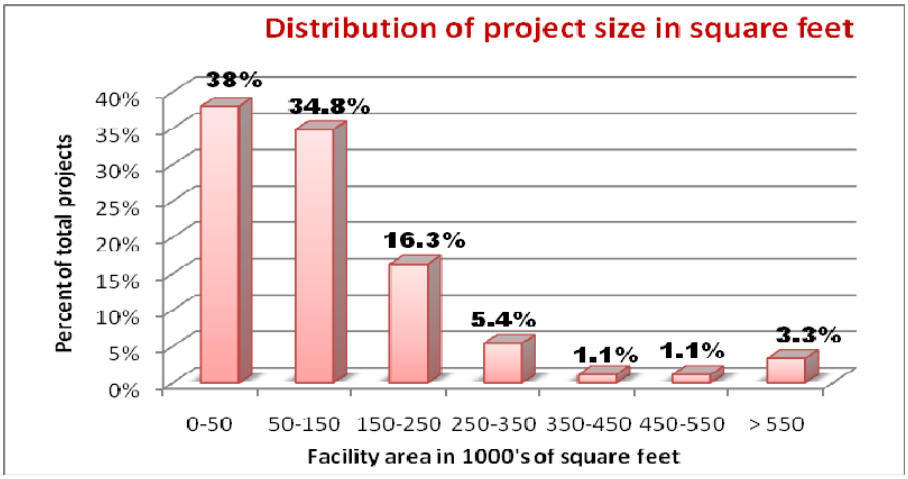

Figure 4.2: Distribution of project size in square feet

Project data was collected from two types of client, public and private. Public owners included organizations like Public Works Department (PWD), Lahore Development Authority (LDA), Capital Development Authority (CDA), Communication and Works Department (C&W) and Pakistan Housing Authority (PHA), etc. Private owners included organizations like Bahria Town, Eden Builders, Emaar Pakistan, Defence Housing Authority (DHA, Islamabad), etc. Figure 4.3 shows that 62 percent of the 92 projects surveyed were publicly owned and 38 percent were privately owned. It was difficult to collect data directly from project owners in some of the projects; therefore consultants were approached to collect the same.

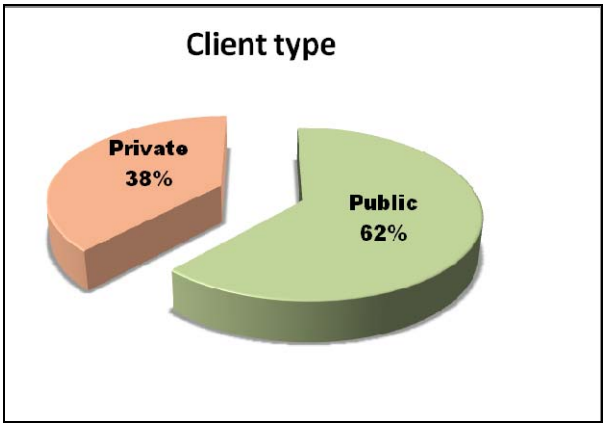

Figure 4.3: Client type

The data was collected on building projects comprises of 35 residential buildings, 8 commercial buildings, 43 public service buildings and 6 other building projects. The summary of the selected project type is given in Table 4.2.

Table 4.2: Summary of Selected Project Type

	Project Delivery Method		
Project Type	Design-Bid-Build	Design-Build	**Total**
Residential Buildings	19	16	**35**
Commercial Buildings	2	6	**8**
Public Service Buildings	24	19	**43**
Other	1	5	**6**
Total	**46**	**46**	**92**

The result of pricing method selected by the owners indicate that 12% of all the projects used Lump sum contracts , 47.8% Unit price, 28.2% Schedule price and 12% other (based on percentage above or below the priced tender and labour rate) construction contract. Figure 4.4 represents the distribution of contract type used in the construction project.

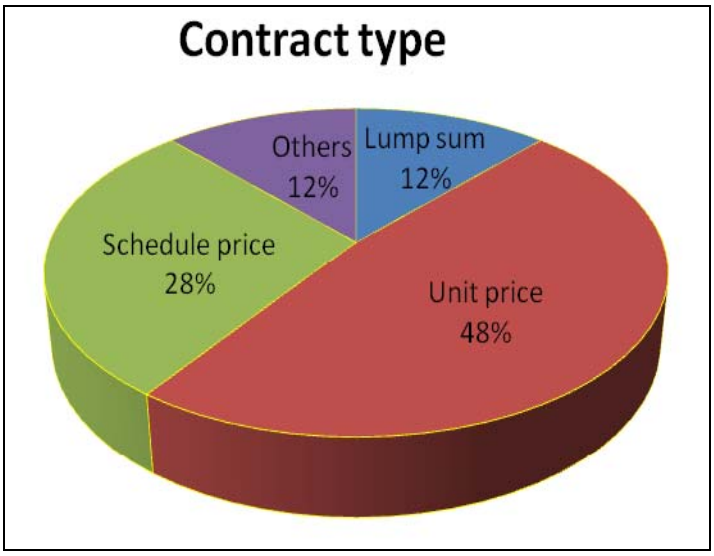

Figure 4.4: Contract type

4.2 PROCUREMENT PRACTICES BY PROJECT DELIVERY METHOD

In response to Question "Was there prequalification process followed for contractor selection", out of total 92 projects, prequalification of contractors was carried out on 36 design-bid-build projects and, on 18 design-build projects as shown in Table 4.3. No prequalification was carried out for rest of the projects. The graphical representation is also shown in Figure 4.5.

Table 4.3: Prequalification of Contractor Selection

	Pre-qualification		
Project delivery method	Yes	No	**Total**
Design-bid-Build	36	10	**46**
Design-build	18	26	**44**
Total	**54**	**36**	**90**

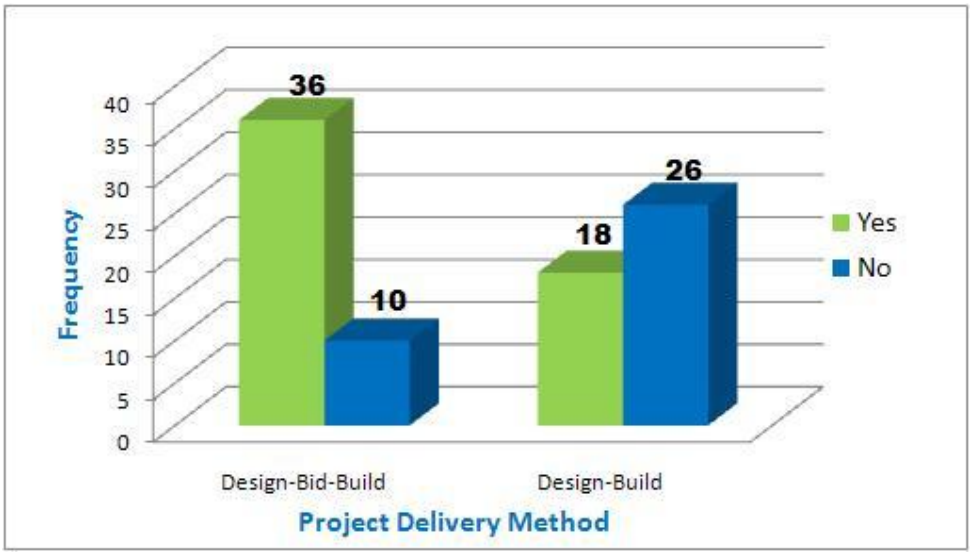

Figure 4.5: Prequalification of contractor selection by project delivery method

In response to question regarding selection of procurement method the client responded that the contractors were selected either through open competitive bidding or by negotiation. In Pakistan, like many other countries including the U.S., it is mandated by legislation that construction contracts for public work projects be procured using a competitive sealed bidding process and awarded using a low-bid system (Ahmed et al. 2009).

Table 4.4 shows that on 44 design-bid-build and 27 design-build projects, contractors were selected through open competitive bidding and through negotiation contractors were selected for only 2 design-bid-build and 20 design-build projects. The graphical representation is also shown in Figure 4.6.

Table 4.4: Procurement Method

	Procurement method		
Project delivery method	Open competitive bidding	Negotiated tendering	**Total**
Design-bid-Build	44	2	**46**
Design-build	24	20	**44**
Total	**70**	**20**	**90**

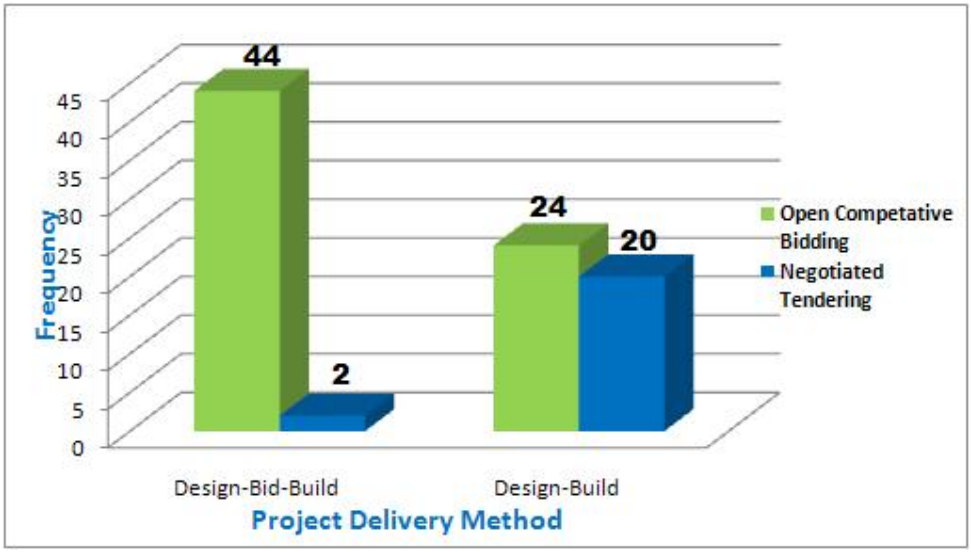

Figure 4.6: Procurement method by project delivery method

The results in the Table 4.5 show the method of adoption by the client for open competitive bidding. On most of the projects Single stage-One envelope bidding procedure was used for the evaluation of contractor. 41 out of 44 design-bid-build and 14 out of 24 design-build projects used single stage one envelope procedure. Single stage- two envelop procedure was employed for only 3 design-bid-build and10 design-build projects. The graphical representation of results is shown in Figure 4.7.

Table 4.5: Methods Adopted for Open Competitive Bidding

	Procedure for open competitive bidding		
Project delivery method	Single stage-One envelope procedure	Single stage-Two envelope procedure	**Total**
Design-bid-Build	41	3	**44**
Design-build	14	10	**24**
Total	**70**	**20**	**90**

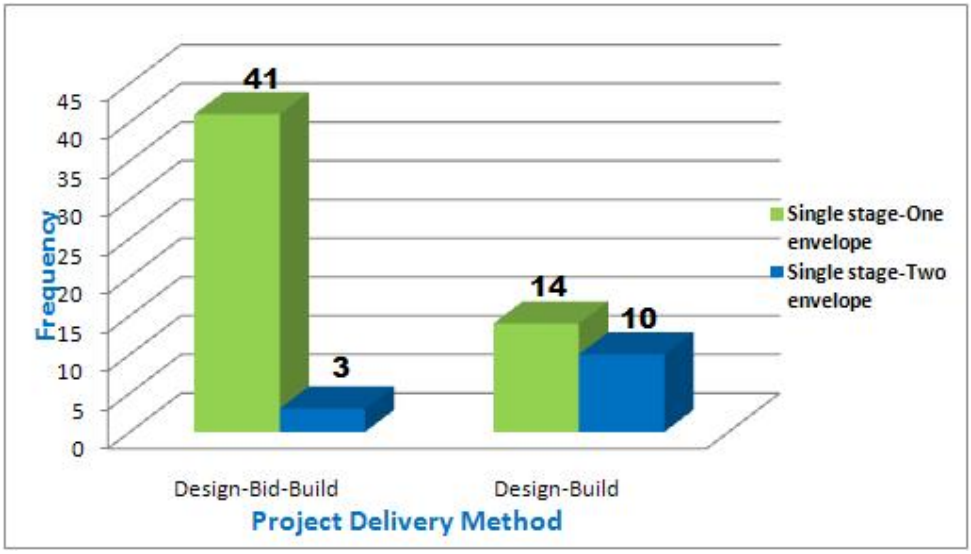

Figure 4.7: Methods adopted for open competitive bidding by project delivery method

47.8% of design-bid-build projects were awarded to the lowest bidders while the same tradition did not follow in awarding contract to the lowest bidder for design-build projects (Table 4.6). The traditional low-bid approach tends to promote more adversarial relationships rather than cooperation or coordination among the contractor, the designer and the owner, and the owner generally faces increased exposure to contractor claims over design and constructability issues (Ahmed et al. 2009).

Almost half of the design build projects were awarded to the lowest bidder where as remaining were awarded to other than lowest bidders. The graphical representation of results is shown in Figure 4.8.

Table 4.6: Lowest Bidder Selection

	Lowest bidder		
Project delivery method	Yes	No	**Total**
Design-bid-Build	44	2	**46**
Design-build	20	21	**41**
Total	**64**	**23**	**87**

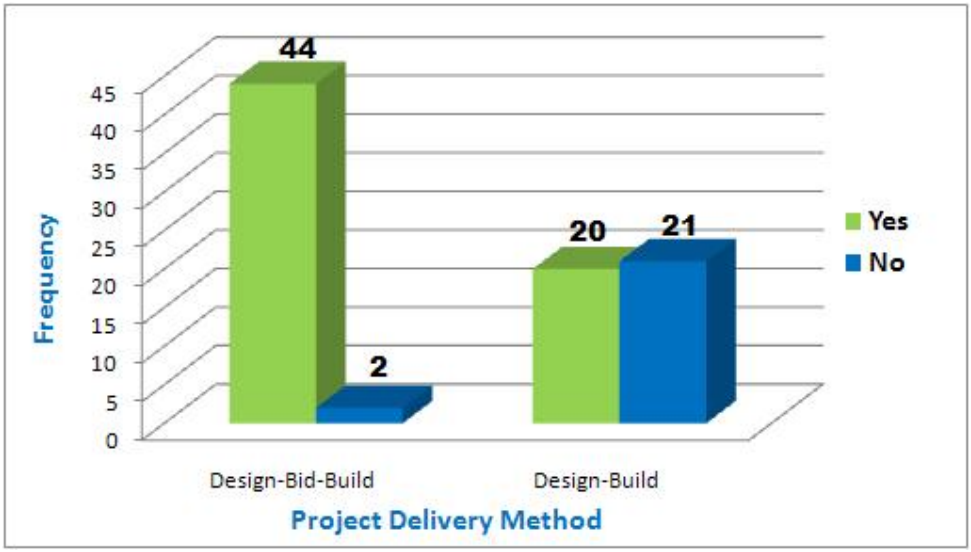

Figure 4.8: Lowest bidder selection by project delivery method

4.3 DISPUTES REPORTED AND SETTLEMENT BY PROJECT DELIVERY METHOD

It was interesting to note that very few disputes were reported in both types of project delivery methods (Table 4.7). Results reveal that almost same numbers of disputes were raised in both project delivery methods. Thereby signifying that the project delivery method has no affect on raising of disputes. The graphical representation of results is shown in Figure 4.9.

Table 4.7: Disputes Reported

	Disputes reported		
Project delivery method	Yes	No	**Total**
Design-bid-Build	15	31	**46**
Design-build	14	30	**44**
Total	**29**	**61**	**90**

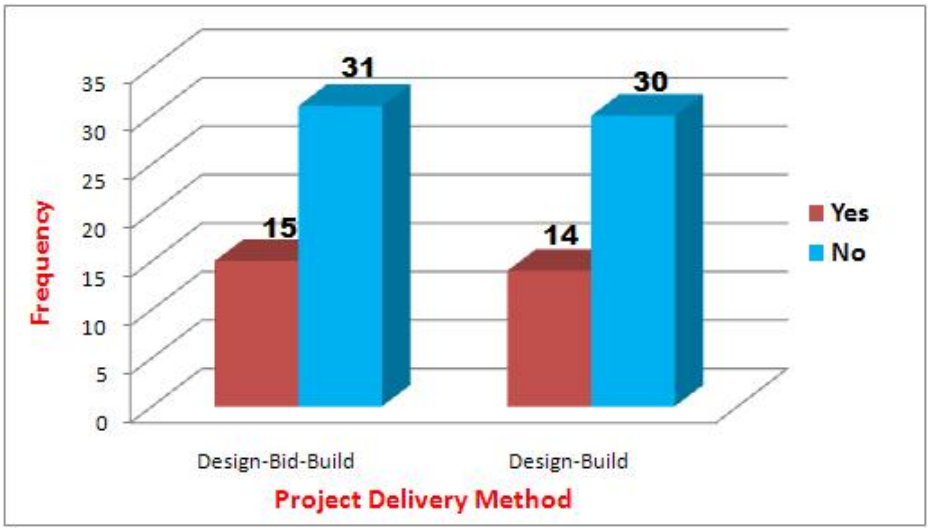

Figure 4.9: Disputes reported

Also the same trend was observed (Table 4.8) for the settlement of disputes in both project delivery methods. Engineer's decision and amicable settlement both were almost equally used for dispute settlement. The graphical representation of results is shown in Figure 4.10.

Table 4.8: Disputes Settlement

	Disputes settlement		
Project delivery method	Engineers Decision	Amicable Settlement	**Total**
Design-bid-Build	7	8	**15**
Design-build	8	7	**15**
Total	**15**	**15**	**30**

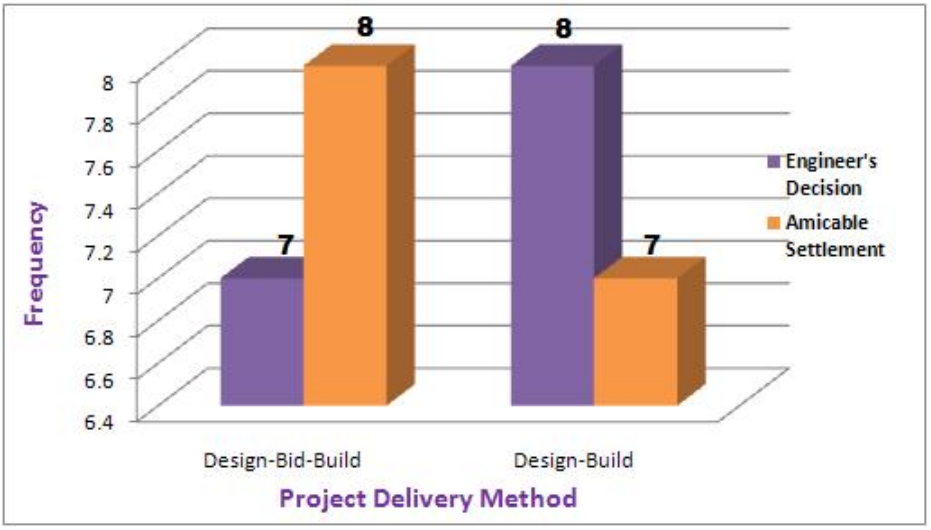

Figure 4.10: Disputes settlement by project delivery method

4.4 GENERAL CONDITIONS OF CONTRACT BY PROJECT DELIVERY METHOD

Table 4.9 summarizes the results for use of conditions of contract by project delivery methods. From the results it is evident that FIDIC form of contract was used for 26% design bid build and only 4% for design build projects. It is interesting to note that departmental conditions of contract were mostly used for design-build projects.

Table 4.9. Use of Conditions of Contract

	Conditions of Contract			
Project delivery method	FIDIC	PEC Standard format of contract	Departmental conditions of contract	**Total**
Design-bid-build	24	7	15	**46**
Design-build	4	3	39	**46**
Total	**28**	**10**	**54**	**92**

The results shown in Table 4.10 indicate that the trend of inclusion of bonus clauses in the construction contracts is very low. The absence of this clause affects the contractor performance as well and leads to schedule overrun. The presence of this clause greatly impacts the project performance, in particular completion on time (El Wardani et al. 2004).

Table 4.10: Use of Bonus Clause

	Bonus clause		
Project delivery method	Yes	No	**Total**
Design-bid-Build	12	34	**46**
Design-build	12	32	**44**
Total	**24**	**66**	**90**

It is worth noting that liquidated damages clause was not applicable in 30 % of design-build projects and in majority of these projects departmental conditions of contract was used (Table 4.11). The amount of liquidated damages was recovered or deducted from the contractor according to clause "the Liquidated damage for the whole works is 0.1% of the final contract price per day. The maximum amount of liquidated damages for the whole works is 10% of the final contract price".

Table 4.11: Use of Liquidated Damages Clause

	Liquidated Damages Clause		
Project delivery method	Yes	No	**Total**
Design-bid-Build	37	9	**46**
Design-build	17	27	**44**
Total	**54**	**36**	**90**

Escalation clause was included for majority of the design bid build projects. However, this clause was used for nearly half of the selected design build projects as shown in Table 4.12. Escalation was calculated according to Pakistan Engineering Council (PEC) formula for most of the projects and other methods was used for the calculation of escalation on remaining projects.

Table 4.12: Use of Escalation Clause

	Escalation Clause		
Project delivery method	Yes	No	**Total**
Design-bid-Build	39	7	**46**
Design-build	24	20	**44**
Total	**63**	**27**	**90**

4.5 COST AND SCHEDULE PERFORMANCE METRICS RESULTS

Using descriptive statistics tests, the mean values for all the cost and schedule performance metrics were compared. Outliers present within the data set were replaced with appropriate valid values (Maximum and minimum). Box plots were also plotted to compare project delivery systems graphically.

4.5.1 Unit Cost

The project unit cost, by nature, varies immensely from one project to another according to the scope definition of the project. Figure 4.11 illustrates the result of data analysis showing that design-build projects had a mean unit cost less than design-bid-build projects.

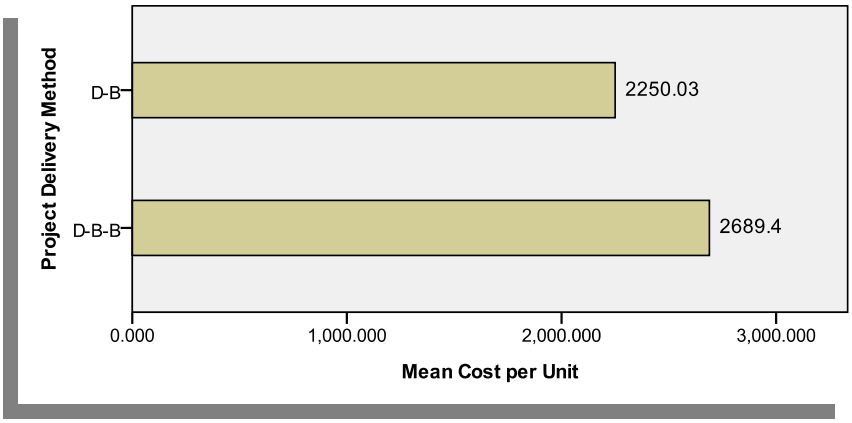

Figure 4.11: Mean unit cost by project delivery method

By using descriptive statistics tests, the unit cost results of central tendency and the measure of dispersion were compared for both project delivery methods. From results (Table 4.13), it is clear that, design-bid-build projects had greater unit cost mean and median values than the design-build.

It is shown in Table 4.13 that median value is nearly equal to mean in both project delivery methods; therefore data was nearly normally distributed. Range is calculated by the difference of maximum and minimum value in the data set.

Table 4.13: Descriptive Results of Unit Cost

Project delivery method	N	Mean	Median	Std. Deviation	Minimum	Maximum	Range
Design-bid-Build	43	2689.42	2622.47	985.97	1028.84	4871.05	3842.20
Design-build	42	2250.03	2068.88	1240.44	309.06	5000.00	4690.93

The unit cost variability within the data set can be visually analyzed by box plot in Figure 4.12. The center horizontal line in each box plot represents the median value for unit cost. Each box stretches from the lower hinge (defined as the 25th percentile) to the upper hinge (the 75th percentile) and therefore contains the middle half of the sample data in the distribution.

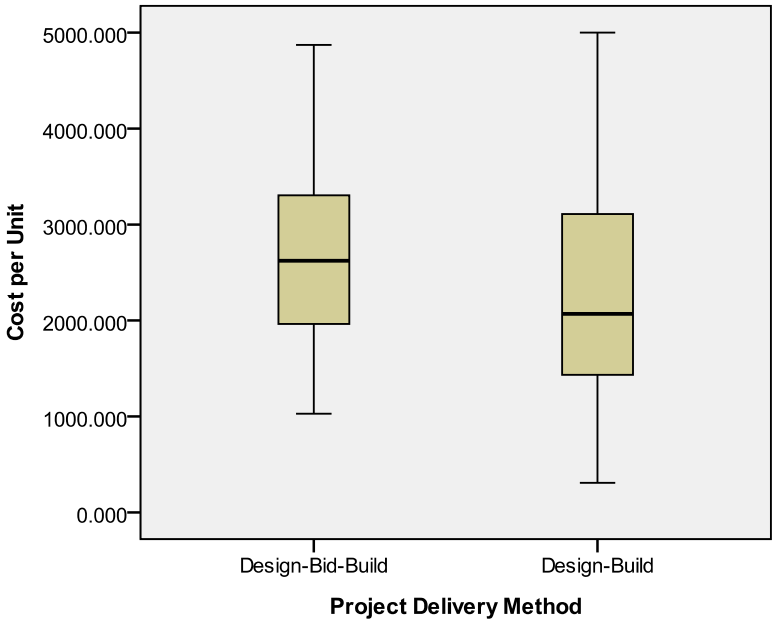

Figure 4.12: Box plot for unit cost

From Figure 4.12 it can be seen that 25 percent of design-bid-build and design build projects had unit cost over Rs 3400/ ft² and Rs 3100/ ft², respectively, while 25 percent of design-bid-build and design build projects fall at below Rs 1900/ ft² and Rs 1400/ ft² unit cost, respectively. This implies that the unit cost of projects using design-bid-build is greater than the projects using design-build method.

The spread of cost performance across the cases was relatively wide. A large proportion of the variation could be explained by major differences in the nature of the buildings. Further analysis of the data showed potentially interesting features. For the design-build sample, large buildings had a relatively cheaper cost/ft² than smaller

buildings. This could be because the design-build project delivery method can achieve economies of scale and benefits from the fast tracking and preconstruction services. The maximum values of design build projects are greater than design-bid-build projects. This was mainly due to the reason that projects were complex in nature involving unique design element, construction techniques and less trained labour.

4.5.2 Cost Growth

Design-build projects had less cost growth than design-bid-build. In Figure 4.13 the results indicate that design-build considerably outperformed design-bid-build in terms of sample cost growth.

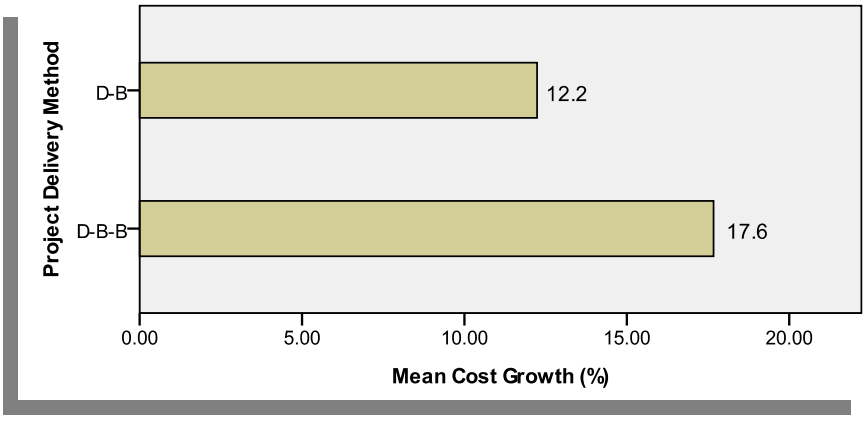

Figure 4.13: Mean cost growth by project delivery method

It can also be seen graphically from box plot of design build delivery method (Figure 4.14) that first quartile Q_1 is nearly about at zero cost growth, indicating that the projects using design build significantly experiencing less cost growth than design-bid-build projects. Figure 4.14 indicates that data set of project delivery method using design-bid-build method is highly skewed.

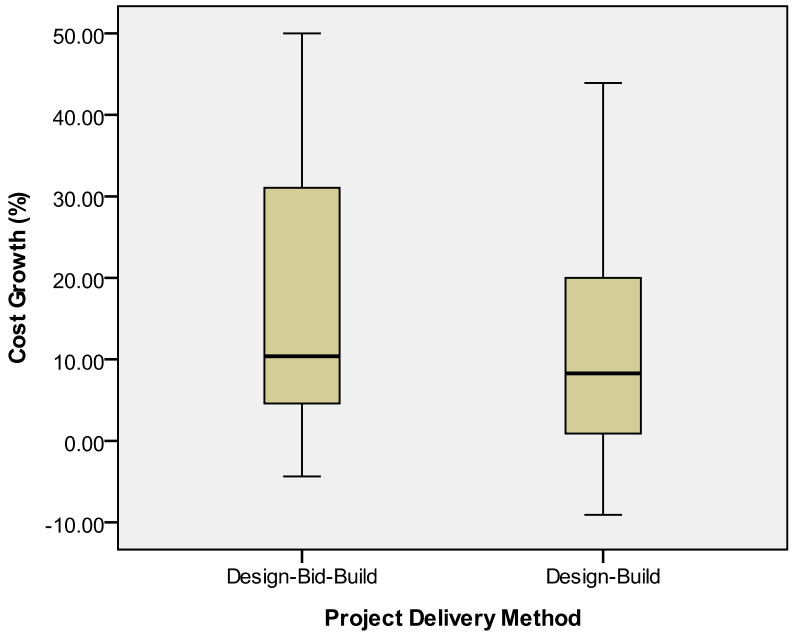

Figure 4.14: Box plot for cost growth

Figure 4.15 shows that 44.56% of the projects using design build experienced absolute change in cost (cost reduction or increase), while 47.83% of the projects using design bid build experienced cost growth.

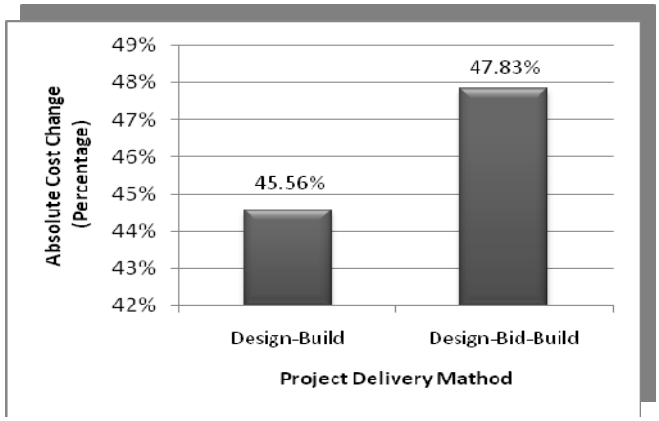

Figure 4.15: Absolute change in cost versus project delivery method

Figure 4.16 presents the percentage of projects whose final costs exceeded the contract price by more than five percent, those that fell within plus or minus five percent of contract price and those under ran contract price by more than five percent. Completion on contract price indicates whether one delivery system consistently provided clients with greater cost certainty (Konchar and Sanvido 1998). Across the entire sample of projects, design-bid-build projects experienced over ran by more than

five percent of the contract cost (Figure 4.16). However, from Figure 4.16. it is evident that design-build projects were more likely to be completed within five percent of the contract price than projects using design-bid-build projects.

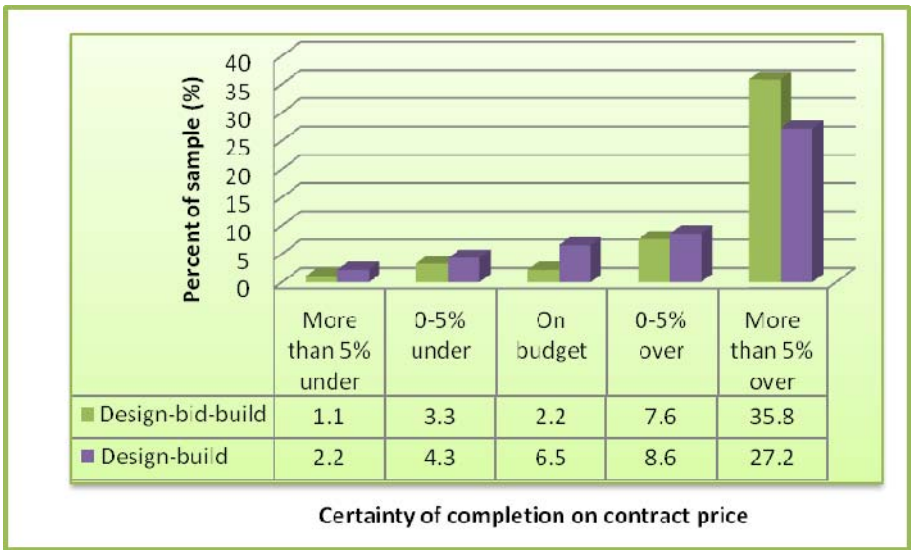

Figure 4.16: Certainty of completion on contract price

One of the possible reasons that the projects executed by the design-build project delivery method had less cost growth was probably because of more opportunity to use innovative procedures to construct the facility that could result in cost saving for the contractor. Also, the improved communication between the contractor and the designer allowed for a better and positive constructability review that reduced the need for revisions and changes during the construction phase (Ibbs et al 2003). It is interesting to note that the maximum value of cost growth of design bid build project was 49.26 %, however, the project contract award cost was 171 million rupees and final project cost was 255 million rupees. This effect was due to the additional changes in scope of work. Inevitably, a construction contract will have change orders and minimizing the impact of these changes on the overall cost of the project is important (Hale et al 2009). When these results (Figure 4.16) were compared to those highlighted in the other studies (Pocock and Liu 1996; Konchar and Sanvido 1998 and Ibbs et al 2003) confirmed that design build projects had less cost growth than design bid build project.

4.5.3 Schedule Growth

Regarding the schedule growth metrics, the analysis showed that the design-bid-build projects had a mean schedule growth greater than design-build projects as shown in Figure 4.17.

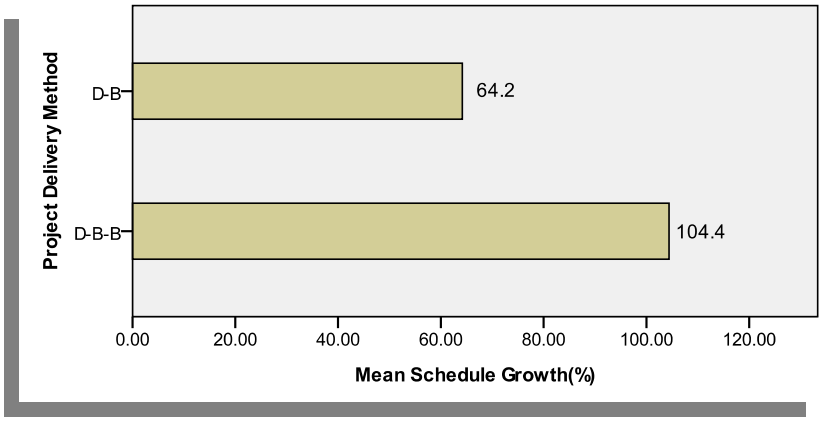

Figure 4.17: Mean schedule growth by project delivery method

Figure 4.18 shows box plots for schedule growth by project delivery system. The distribution of each sample shows that both project delivery methods had minimum zero percent schedule growth value. But the median value of design-bid-build projects was two times greater than design-build projects (Appendix IV).

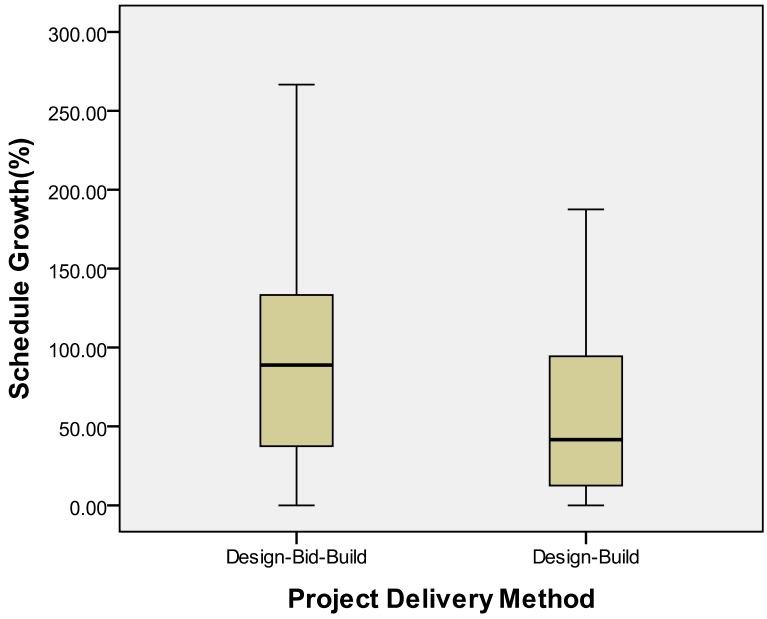

Figure 4.18: Box Plot for Schedule growth

42.40% of the projects using design build experienced Schedule growth, while 46.74% of the projects using design bid build experienced Schedule growth as shown in Figure 4.19.

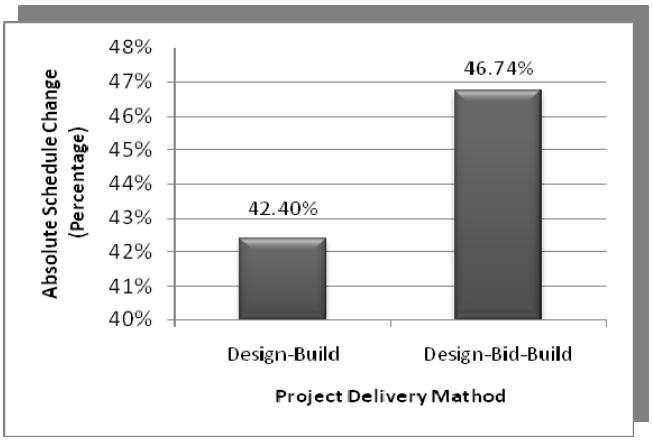

Figure 4.19: Absolute change in schedule versus project delivery method

Figure 4.20 illustrates the percentage of projects whose final schedule duration exceeded the planned schedule by more than five percent, those that fell within five percent of the planned schedule and those that under ran the planned schedule by more than five percent. 44.45% of all design-bid-build and 38% of all design-build projects were more than five percent behind the planned schedule. Out of 11.95% design-build projects 7.6 % projects finished on time and 4.35% experienced highly significant schedule saving. This result is consistent with the findings of Molenaar et al. (1999).

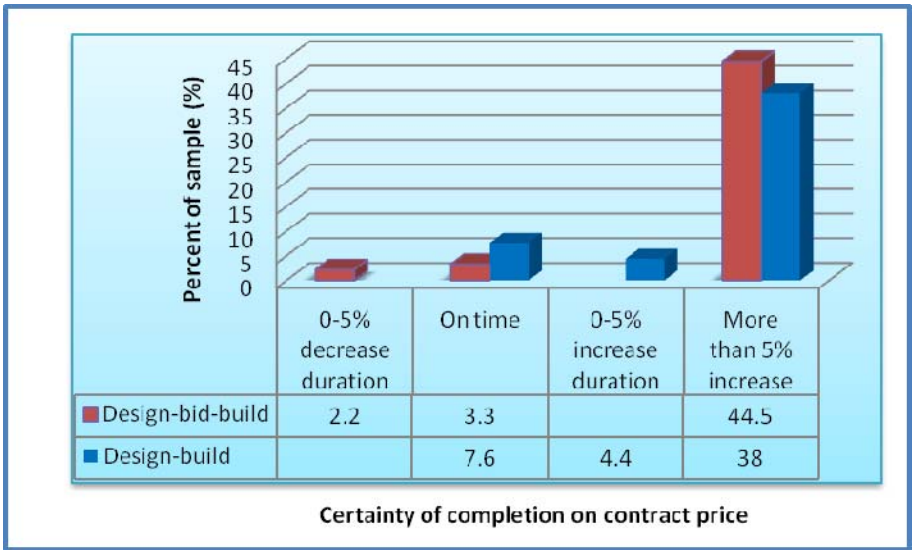

Figure 4.20: Certainty of completion on time

The trend of design completion for the projects executed by design-bid-build and design-build was also evaluated as shown in Figure 4.21. All of the design-bid-build projects were awarded after their design completion. There was involvement of contractors in early stage of schematic design and fast tracking for design build projects. The benefit of having early construction input or to having a team well suited to handle changes was only realized when the owner had the capability to manage an integrated, team based approach (Konchar and Sanvido 1998).

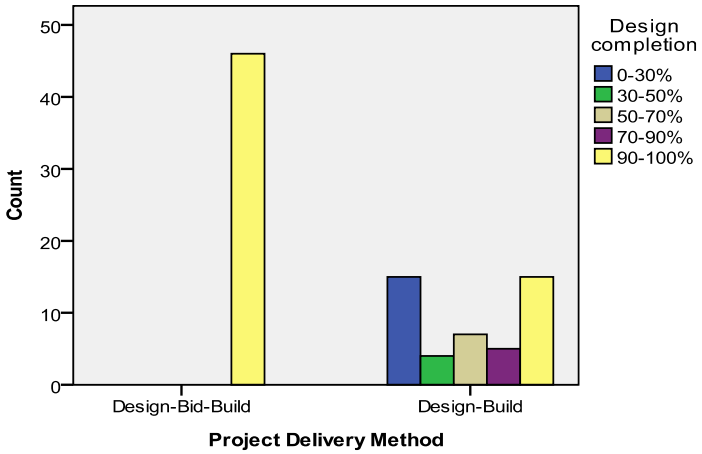

Figure 4.21: Percentage of design completion by project delivery method

4.5.4 Construction Speed

Results indicated that construction speed of design-build projects was significantly faster than design-bid-build projects. Projects executed by design build appeared to have better schedule performance with faster construction speed as shown in Figure 4.22. Also, Figure 4.23 illustrates that box plot of design build projects was more positively skewed.

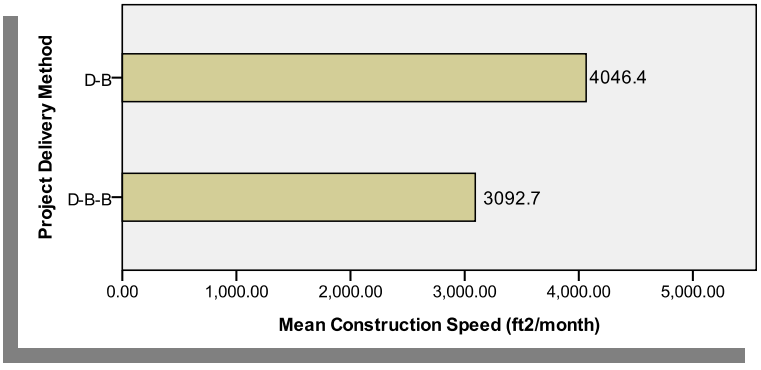

Figure 4.22: Mean construction speed by project delivery method

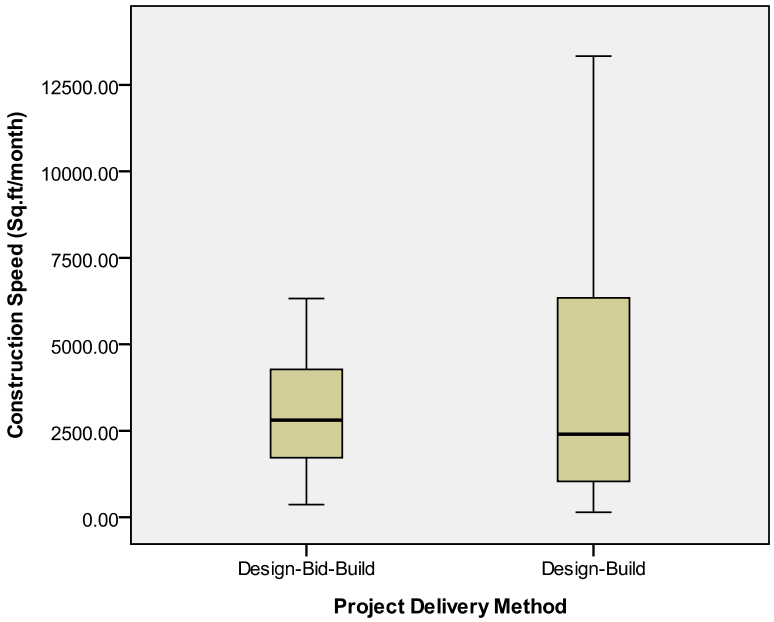

Figure 4.23: Box Plot for Construction speed

Unusual results were noticed for median and minimum value construction speed (Figure 4.23), it was observed to be faster for the design-bid-build method and slowest for the design-build project delivery method. This result was contrary to the expected result and may be attributed to the other parameters, such as building type, size, complexity, etc. It is worth noting that the spread in the case of design build construction speed, as shown in Figure 4.23, is very high indicating that some projects had very fast construction speed, therefore, resulted in the better schedule performance.

4.6 INDEPENDENT t-TEST

The Independent t-test was conducted to determine whether there is a statistically significant difference between the means of two project delivery methods. The SPSS t-test results test the equality of variances (Levene's test) and the t-value for both equal- and unequal-variance. Normal distribution and equal variance assumption were checked to determine the validity of the data collected for Independent t-test.

4.6.1 Normal Distribution Assumption

Cost and time performance metrics data of both project delivery methods was tested for normality of distribution (Appendix V). All metrics, with the exception unit cost metric, did not follow a normal distribution. Table 4.14 showing the results of testing the cost and time metrics using the Kolmogorov-Smirnov and Shapiro-Wilk normality tests, conducted at a confidence level of 95%, revealed that the p-value of unit cost for both project delivery methods is greater than 0.05 (level of significance) resulting in acceptance of the null hypothesis that the data is normally distributed. However, the p-values for the other metrics were smaller than 0.05, signifying that the data was deviated from a normal distribution.

Table 4.14: Tests of Normality

Performance metrics	Project delivery method	Kolmogorov-Smirnov				Shapiro-Wilk			
		Statistic	df	Sig.	Remarks	Statistic	df	Sig.	Remarks
Unit Cost (Rs/ft²)	D-B-B	.080	43	.200*	InSig.	.973	43	.404	InSig.
	D-B	.132	42	.063	InSig.	.948	42	.055	InSig.
Cost Growth (%)	D-B-B	.176	46	.001	Sig.	.882	46	.000	Sig.
	D-B	.146	46	.016	Sig.	.914	46	.002	Sig.
Schedule Growth (%)	D-B-B	.137	45	.033	Sig.	.897	45	.001	Sig.
	D-B	.175	46	.001	Sig.	.878	46	.000	Sig.
Construction Speed (ft²/month)	D-B-B	.099	45	.200*	InSig.	.940	45	.021	Sig.
	D-B	.197	46	.000	Sig.	.852	46	.000	Sig.

*. This is a lower bound of the true significance.

The results of all Sig. values of the Kolmogorov-Smirnov Test and the Shapiro-Wilk Test were alike (greater or less than 0.05), but only differ in the case of construction speed of design-bid-build method.

4.6.2 Equal Variance Assumption

The p-values obtained from the Levene's test for equal variances were greater than the significance level, α = 0.05, for unit cost and cost growth metrics. It was concluded from the results (Table 4.15), that the cost performance metrics possess equal variances. Schedule growth and construction speed "Sig." values are less than 0.05, indicating that the variances are unequal as shown in Table 4.15.

Table 4.15: Levene's Test Results

	Unit Cost (Rs/ft²)	Cost Growth (%)	Schedule Growth (%)	Construction Speed (ft²/month)
p-value	0.224	0.067	0.022	0.000

4.6.3 Independent t-test Results

The independent t-test was conducted, at 95% confidence level, to compare the mean difference of project delivery's performance metrics. It was observed from the results (Table 4.16) that p-values for the unit cost, cost growth and construction speed were greater than α = 0.05 (Level of significance) and less than 0.05 for schedule performance metrics. It is concluded that unit cost, cost growth and construction speed metrics are statistically insignificant resulting in the acceptance of null hypothesis (Ho: μDesign-Bid-Build = μDesign-Build), that there is no difference between the mean of two project delivery methods. However, the schedule growth of design-bid-build projects (104.36 ± 85.32) was significantly higher than design-build projects (64.18 ± 59.92) (t (78.77) = 2.595, P = 0.011).

Table 4.16: Independent Samples Test Results

	Unit Cost (Rs/ft²)	Cost Growth (%)	Schedule Growth (%)	Construction Speed (ft²/month)
p-value	.074	.103	.011	.136
Remarks	InSig.	InSig.	Sig.	InSig.

This difference is more likely due to the fact that design build projects were executed by fast tracking and single point responsibility and provide opportunity for contractor to employ constructability. As noted by Songer and Molenaar 1996, owners feel very strongly that design-build should be selected to shorten duration. On the issue of saving time by applying the design build approach, the results also confirmed other studies and literatures (Konchar and Sanvido 1998; Molenaar et all. 1999).

Chapter-5

CONCLUSIONS & RECOMMENDATIONS

5.1 CONCLUSIONS

This research study compares the cost and schedule performance of design-bid-build and design-build delivery method, using project data collected from 92 building construction projects of Pakistan. The results of the statistical analysis are presented in two major parts. First, the current procurement practices and delivery methods adopted in the selected construction projects are evaluated. Second, the performance of design-bid-build and design-build project delivery methods in terms of cost and schedule is compared.

After statistical analysis of the collected data using SPSS, the following conclusions were drawn:

- Pre-qualification of contractor selection is being mostly used for the design-bid-build projects rather than design-build projects. Almost for the design-bid-build projects contractors were selected through open competitive bidding, while for some design build projects contractors were selected by negotiation.
- Single stage one envelope bidding procedure is the main open competitive bidding procedure used for most of the procurement. Single stage two envelope bidding procedure was used where the bids were to be evaluated on technical and financial grounds and price was taken into account after technical evaluation.
- The trend of using PEC conditions of contracts was found less as compared to FIDIC because former were reported to be biased in favour of owners/clients. Incentive clauses were not included for 74% of the total projects due to the absence of these clauses in FIDIC/PEC Conditions of Contract
- Very few disputes were reported in both types of project delivery methods thereby signifying that the project delivery method has no effect on raising of

disputes. Engineer's decision and amicable settlement both were almost equally used for dispute settlement.

- No significant difference was found from t-test analysis in unit cost, cost growth and construction speed between the two project delivery methods except schedule growth metric. This difference is more likely due to the fact that design build projects were executed by fast tracking and single point responsibility. Also, results indicated that the design-build projects had large construction speed, therefore, resulted in better schedule performance.

5.2 RECOMENDATIONS

1. The selection of the most appropriate procurement method and team selection can ensure a smooth project delivery process and eliminate problems during construction.

2. Develop new methods to contract award procedure based on price and performance selection rather than existing low bid selection.

3. The public owners should also consider adoption of non-conventional project delivery methods.

4. Standard procurement methods for design-build delivery methods should be prepared by Government agencies such as PEC, PEPRA for public sectors.

5. Two stage bidding procedure for the contractor selection should be adopted for more fair contractor selection by both public and private owners.

6. Enforcement of liquidated damages clauses for completion of work within stipulated duration.

7. Incentive clauses should be added in the General Conditions of Contracts for early completion of project.

5.3 FUTURE RESEARCH

1. The scope of the study was to compare building project performance by univariate analysis. Future studies may be carried out which include multivariate analysis.

2. In the present study performance of project delivery methods were not compared with respect to similar facility type due to insufficient data. Future studies may be carried out by selecting similar facility type at the same location.

3. Project delivery performance can be compared for public and private owners.

4. In this study the percent design complete when construction entity joins the team for design-build projects was investigated. The impact of the early involvement of contractors on project performance in terms of cost and schedule growth can be evaluated in further studies.

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APPENDIX I

MS RESEARCH THESIS QUESTIONNAIRE

SECTION I: RESPONDENT INFORMATION

Name of the respondent: _____

E-mail Address: _____

Phone number: _____

SECTION II: PROJECT CHARECTERISTIC

Project Name: _____

Year of Completion: _____

Project Location: _____

Name of the Client (Public / Private): _____

Nature of Project

- ☐ Residential Building (House/ Apartment / Flat)
- ☐ Commercial Building (Office / Shopping Center / Hotel)
- ☐ Public Service Buildings (Educational Institutional / Hospital)
- ☐ If other, please specify: _____

Project gross covered area (ft^2): _____

No. of floors _____

SECTION III: PROJECT DELIVERY METHOD

1. **Which of the following project delivery method was used for this project by the client/owner?**

   ☐ Design - Bid – Build

   ☐ Design and Build

SECTION IV: PROCUREMENT METHOD

2. **Was there a prequalification process for contractors?**

   ☐ Yes ☐ No

3. **Which of the following procurement method was used for the project?**

   ☐ Open competitive bidding/tendering

   ☐ Negotiated Tendering

4. **If "Open competitive bidding", then procedure for open competitive bidding was:**

   ☐ Single stage – one envelope procedure

   ☐ Single stage – two envelope procedure

   ☐ Two stage bidding procedure

   ☐ Two stages - two envelope bidding procedure

5. **Whether the successful bidder was lowest bidder?**

   ☐ Yes ☐ No

SECTION V: CONSTRUCTION CONTRACT TYPE

6. **Which of the following type of construction contract was used for this project by the client/owner?**

   ☐ Lump Sum

   ☐ Unit Price

   ☐ Schedule Price

   ☐ If other, please specify: _____

SECTION VI: COST

Contract cost of the project: PKR. _____
(Original budget)

Actual Final project cost: PKR. _____

SECTION VII: SCHEDULE

Please provide the following schedule information

Construction start date: _____

Substantial completion date: _____

Construction end date: _____

What percentage of design was complete at the time of starting the construction work of the project? _____% (if the construction company was not involved in the design phase, enter 100%)

SECTION VIII: DISPUTES

7. **Did any dispute arise during the project?**

   ☐ Yes ☐ No

8. **How was the dispute settled?**

   ☐ Engineer's Decision

   ☐ Amicable Settlement

   ☐ Arbitration

SECTION IX: GENERAL CONDITIONS OF CONTRACT

9. **Which of the following conditions of contract were used for this project?**

   ☐ FIDIC

   ☐ PEC Standard format of Contract

   ☐ Departmental Conditions of Contract

10. **Did the contract include any incentive clauses for completion of work on schedule?**

    ☐Yes ☐ No

11. **If the contract included a liquidated damages clause, please indicate its amount /day: Rs _____**

12. **Did the contract include any escalation clause?**

    ☐ Yes ☐ No

13. **If "Yes", what mechanism of determining escalation cost was clearly prescribed in the contract? (Please Specify)**

    _____

SECTION X: LESSON LEARNED

Q1. Did the delivery system enhance or hindered your ability to perform? If "Yes", How?

_____

Q2. Could this project have been better delivered or more successful? If "Yes", How?

_____

Q3. Did the project meet the intended needs?

_____

Q4. Describe any unique features about this building that influenced its cost, schedule and quality?

_____

APPENDIX II

DATA SHEET

Project #	Project Name	No. of Floors	Year of Completion
1	FGEHF Package 1	5	2011
2	Package 2	4	2009
3	Package 3	4	2011
4	Package 4	4	2011
5	Package 5	4	2010
6	Package 6	5	2011
7	Package 7	5	2011
8	CP-3 (LOT-2)	1	2009
9	CP-3 (LOT-3)	1	2009
10	CP-4 (LOT-1)	1	2010
11	CP-4 (LOT-2)	1	2010
12	CP-4 (LOT-4)	1	2010
13	CP-4 (LOT-5)	1	2010
14	CP-2A (LOT-5)	1	2010
15	CP-2A (LOT-6)	1	2010
16	PHA Construction of D Type Apartment, Isb.	4	2010
17	PHA Construction of E Type Apartment	4	2009
18	PEL Transformer Unit II	1	2009
19	Aitchison School, Lhr	3	2010
20	Aitchison School, Lhr	3	2010
21	NBS (NIMS), NUST, Isb.	2	2008
22	Hostel Pkg-I	4	2008
23	Hostel Pkg-II	4	2008
24	NIT & IESE	2	2008
25	SEECS (NIIT)	2	2008
26	CCE&MS (SCME)	3	2008
27	Staff Res Pkg-I		2010
28	Staff Res Pkg-II		2010
29	Staff Pkg III		2010
30	Hostel Pkg-III	4	2010
31	IGIS, RIMMS & RCMS	3	2008
32	IAEC, IT & CCT&SM		2010
33	IME & DOR		2010
34	Population House, Isb	3	2008
35	Alma Townhouses, Isb	2	2011
36	PNRA HQ Building, Isb.	7	2008
37	Islamabad Club (Multipurpose Hall)	2	2007
38	Club Arcade	2	2006

39	LG & RD, Isb	7	2007
40	NBP, Isb	6	2010
41	IT Tower, Lhr	10	2010
42	Islamabad Stock Exchange Tower	22	2009
43	PHA Construction of C Type Apartment	4	2010
44	Creek City 12 Towers DHA, Karachi	20	2010
45	Residential Accommodation of FG Employee, Isb.	4	2011
46	University of Gujarat	3	2010
47	CP (1) Earthquake Additional Financing Project	1	2010
48	CP-7	4	2010
49	Bahria Guest House/ Hotel, Lhr.	4	2011
50	Telephone Exchange	3	2008
51	Safari Villas	2	2010
52	Bahria School	3	2006
53	Multi Mart	2	2008
54	Houses Meadows	2	2010
55	Safari Mall	2	2008
56	Bahria Hospital	4	2006
57	NIPPON Paints Project	2	2010
58	NISHAT Apparel	3	2011
59	PAPER SACK Plant	1	2006
60	Construction of 48 Family Suites, Isb	7	2010
61	Dada Dairy, Lhr	1	2011
62	Din Commercial Building, Lhr.	8	2010
63	Premium Lather Factory, Lhr.	1	2008
64	Development of Wheat Analytical Lab, Fsd.	2	2009
65	Establishment of Main Building, Fsd.	4	2007
66	Establishment of Doctors Hospital	4	2007
67	Establishment of Nursing Hospital	4	2007
68	Construction of Judicial Complex	1	2009
69	LDA Model school, Lhr.	4	2008
70	LDA Office Building	4	2007
71	LDA Office Building	5	2010
72	LDA Model school	3	2009
73	Building Hall @LDA	1	2011
74	Mirador Villas 1, Isb.	2	2010
75	Mirador Villas 2, Isb.	2	2010
76	Mirador Villas 3, Isb.	2	2011
77	Mirador Villas 4, Isb.	2	2011
78	Const. of Local Centre DHA, Isb.	2	2011
79	Dream Villas Lux. 5 Marla, Lhr.	2	2010
80	Dream Villas Lux 7 Marla	2	2010
81	Eden Builders 10 Marla, Lhr.	1	2011
82	Eden Builders 7 Marla	2	2010
83	Eden Builders 3.5 Marla	2	2011

84	Main Club Building DHA, Isb.	3	2011
85	Family Wing DHA, Isb.	2	2011
86	Administration Block DHA, Isb.	2	2011
87	Construction of Mosque at PM Sec. Isb.	2	2010
88	Construction of 12 Apartments for FMR, Isb.	3	2011
89	Construction of Classrooms & Admin Block, Isb	2	2010
90	Forensic Science Lab, Lhr.	3	2011
91	VIP Hanger @ Old Terminal, Lhr.	1	2007
92	Establishment of Drug Rehabilitation Centre, Multan	2	2009

Project #	WPI Base Year	WPI 2010	Covered Area *(ft²)*	Contract Award Cost *(Million)*	Project Completion Cost *(Million)*
1	262.94	262.94	247500	365.964	350
2	201.1	262.94	123120	150.732	154
3	262.94	262.94	218880	274.704	270
4	262.94	262.94	193600	234.278	230
5	226.49	262.94	206280	272.113	320
6	262.94	262.94	150000	213.469	220
7	262.94	262.94	120000	172.409	180
8	226.49	262.94	35600	75.012	96.926
9	226.49	262.94	45056	93.591	122.659
10	262.94	262.94	31100	80.985	111.816
11	262.94	262.94	17540	49.536	62.793
12	262.94	262.94	30980	75.855	105.475
13	262.94	262.94	20940	34.486	50.929
14	262.94	262.94	27016	72.992	86.607
15	262.94	262.94	18782	54.253	56.804
16	262.94	262.94	98280	174.924	188.158
17	226.49	262.94	43680	80.326	86.924
18	226.49	262.94	350000	250	510
19	262.94	262.94	50600	70.3	75.38
20	262.94	262.94	52000	46.95	53.5
21	201.1	262.94	93500	138.772	187.533
22	201.1	262.94	132549	254.558	272.409
23	201.1	262.94	135989	253.794	277.031
24	201.1	262.94	88128	150.134	211.133
25	201.1	262.94	111535	137.83	229.726
26	201.1	262.94	48501	102.71	140.01
27	226.49	262.94	79728	139.577	160.035
28	226.49	262.94	76389	149.263	156.119
29	226.49	262.94	60313	107.678	119.278
30	262.94	262.94	94698	234.091	268.541
31	201.1	262.94	63270	150.879	189.634
32	226.49	262.94	81889	140.709	142.5
33	226.49	262.94	65525	140.762	142.5
34	201.1	262.94	73461	105	217
35	262.94	262.94	216935	642.407	690.351
36	170.15	262.94	93525	171.45	255.91
37	170.15	262.94	17000	50	53.3
38	124.14	262.94	4000	4	4.8

39	170.15	262.94	87000	215	215
40	226.49	262.94	143000	600	600
41	262.94	262.94	136000	1668	550
42	226.49	262.94	562629	829	976
43	226.49	262.94	318320	184.486	194.458
44	226.49	262.94	3000000	5000	5500
45	262.94	262.94	488024	367	397
46	226.49	262.94	4500000	500	750
47	262.94	262.94	74723	189.115	171.961
48	226.49	262.94	152184	483.91	538.094
49	262.94	262.94	30000	140	150
50	170.15	262.94	22000	4.4	4.4
51	226.49	262.94	2400	2.9	3
52	136.68	262.94	60000	60	65
53	201.1	262.94	45000	120	140
54	226.49	262.94	5000	10	10
55	170.15	262.94	25000	40	42
56	146.18	262.94	48000	10	12
57			90000	340	380
58	262.94	262.94	50000	100	120
59	136.68	262.94	160000	140	152
60	262.94	262.94	101300	289.861	302.298
61	262.94	262.94	250000	185	180
62	201.1	262.94	128000	80.15	85
63	170.15	262.94	245000	85.75	100.25
64	201.1	262.94	14260	15.728	18.37
65	170.15	262.94	230038	282.468	305.712
66	170.15	262.94	40671	38.648	38.648
67	170.15	262.94	32801	30.443	30.443
68	226.49	262.94	13792	22.129	25.345
69	201.1	262.94	19114	45.053	45.456
70	146.18	262.94	65773	29.5	27.92
71	226.49	262.94	50719	75.146	73.61
72	201.1	262.94	72018	87.227	89.385
73	262.94	262.94	4459	24.247	23.666
74	262.94	262.94	246366	699.294	783.058
75	262.94	262.94	252737	719.115	828.753
76	262.94	262.94	175932	486.905	658.499
77	262.94	262.94	229757	626.592	778.47
78	262.94	262.94	404726	794.3	893.749
79	226.49	262.94	2250	3.8	3.938
80	226.49	262.94	3299	5.15	5.318
81	262.94	262.94	209250	189.348	243.6
82	262.94	262.94	299524	266.16	332.598
83	262.94	262.94	296190	289.339	386.092

84	262.94	262.94	43766	119	209
85	262.94	262.94	12400	44	61
86	262.94	262.94	16535	56	96
87	262.94	262.94	4350	6.81	9.8
88	262.94	262.94	46000	164.51	215
89	226.49	262.94	11084	16	15.174
90	262.94	262.94	210000	900	900
91	170.15	262.94	84500	125	133
92	226.49	262.94	33947	32.241	34.404

Project #	Project Cost @ Dec,2010 *(Million)*	Unit Cost *(Rs in million/ft²)*	Unit Cost w.r.t 2010 *(Rs in million/ft²)*	Cost Growth (%)
1	350.000	1414.141	1414.141	-4.36
2	201.356	1635.448	1635.448	2.17
3	270.000	1233.553	1233.553	-1.71
4	230.000	1188.017	1188.017	-1.83
5	371.499	1800.945	1800.945	17.6
6	220.000	1466.667	1466.667	3.06
7	180.000	1500	1500.000	4.4
8	112.525	3160.807	3160.807	29.21
9	142.399	3160.49	3160.490	31.06
10	111.816	3595.37	3595.370	38.07
11	62.793	3579.989	3579.989	26.76
12	105.475	3404.616	3404.616	39.05
13	50.929	2432.139	2432.139	47.68
14	86.607	3205.767	3205.767	18.65
15	56.804	3024.385	3024.385	4.7
16	188.158	1914.51	1914.510	7.57
17	100.913	2310.28	2310.280	8.21
18	592.076	1691.647	1691.647	104
19	75.380	1489.723	1489.723	7.23
20	53.500	1028.846	1028.846	13.95
21	245.201	2622.471	2622.471	35.14
22	356.177	2687.136	2687.136	7.01
23	362.220	2663.601	2663.601	9.16
24	276.058	3132.469	3132.469	40.63
25	300.369	2693.045	2693.045	66.67
26	183.064	3774.444	3774.444	36.32
27	185.790	2330.299	2330.299	14.66
28	181.244	2372.644	2372.644	4.59
29	138.474	2295.922	2295.922	10.77
30	268.541	2835.762	2835.762	14.72
31	247.948	3918.889	3918.889	25.69
32	165.433	2020.212	2020.212	1.27
33	165.433	2524.733	2524.733	1.24
34	283.729	3862.313	3862.313	106.67
35	690.351	3182.294	3182.294	7.46
36	395.469	4228.48	4228.480	49.26
37	82.367	4845.103	4845.103	6.6
38	10.167	2541.711	2541.711	20
39	332.249	3818.949	3818.949	0
40	696.561	4871.053	4871.053	0
41	550.000	4044.118	15277.778	-67.03

42	1133.072	2013.888	20139.203	17.73
43	225.753	709.201	709.201	5.41
44	6385.138	2128.379	2128.379	10
45	397	813.485	813.485	8.17
46	870.701	193.489	193.489	50
47	171.961	2301.313	2301.313	-9.07
48	624.692	4104.845	4104.845	11.2
49	150.000	5000	5000.000	7.14
50	6.800	309.068	309.068	0
51	3.483	1451.168	1451.168	3.45
52	125.045	2084.077	2084.077	8.33
53	183.051	4067.805	4067.805	16.67
54	11.609	2321.869	2321.869	0
55	64.904	2596.175	2596.175	5
56	21.585	449.685	449.685	20
57		4901.722		11.77
58	120	2400	2400.000	20
59	292.412	1827.575	1827.575	8.57
60	302.298	2984.186	2984.186	4.29
61	180	720	720.000	-2.7
62	111.138	868.267	868.267	6.05
63	154.921	632.329	632.329	16.91
64	24.019	1684.357	1684.357	16.8
65	472.430	2053.703	2053.703	8.23
66	59.724	1468.476	1468.476	0
67	47.045	1434.251	1434.251	0
68	29.424	2133.402	2133.402	14.53
69	59.434	3109.455	3109.455	0.9
70	50.221	763.548	763.548	-5.36
71	85.456	1684.899	1684.899	-2.04
72	116.872	1622.812	1622.812	2.47
73	23.666	5307.468	5307.468	-2.4
74	783.058	3178.434	3178.434	11.98
75	828.753	3279.112	3279.112	15.25
76	658.499	3742.918	3742.918	35.24
77	778.470	3388.232	3388.232	24.24
78	893.749	2208.28	2,208.28	12.52
79	4.572	2031.893	2031.893	3.63
80	6.174	1871.714	1871.714	3.26
81	243.600	1164.158	1164.158	28.65
82	332.598	1110.422	1110.422	24.96
83	386.092	1303.528	1303.528	33.44
84	209	4775.396	8794.076	75.63
85	61	4919.355	4919.355	38.64

86	96.000	5805.866	5805.866	71.43
87	9.800	2252.874	2252.874	43.91
88	215.000	4673.913	4673.913	30.69
89	17.616	1589.319	1589.319	-5.16
90	900.000	4285.714	4285.714	0
91	205.531	2432.314	2432.314	6.4
92	39.941	1013.462	1176.563	6.71

Project #	As-Built Construction Start Date	Proposed Completion Date	As-Built Construction End Date
1	Nov,2006	Feb,2008	Jan,2011
2	Nov,2005	June,2007	April,2009
3	April,2006	April,2007	Jan,2011
4	May,2006	May, 2007	Jan,2011
5	Aug,2006	Nov,2007	Jan,2010
6	April,2007	July,2008	Jan,2011
7	April,2007	July,2008	Jan,2011
8	January, 2008	Oct, 2008	Oct, 2009
9	January, 2008	Oct, 2008	Oct, 2009
10	January, 2008	Oct, 2008	Nov, 2010
11	March, 2008	Nov, 2008	Nov, 2010
12	March, 2008	Nov, 2008	Nov, 2010
13	Feb, 2008	Nov, 2008	Nov, 2010
14	June, 2009	March, 2010	Nov, 2010
15	May, 2009	Jan,2010	Nov, 2010
16	June, 2008	June, 2009	August, 2010
17	May, 2008	May, 2009	Dec, 2009
18	Feb, 2008	Feb, 2009	Sep, 2009
19	Dec, 2009	July, 2010	July, 2010
20	Aug, 2009	Aug, 2010	Aug, 2010
21	May,2005	Feb,2007	Sep,2008
22	February, 2006	June,2007	Sep,2008
23	April,2006	Nov.2007	Sep,08
24	Nov,2006	March,2008	Sep,2008
25	May,2005	Feb,2007	Aug,2008
26	February, 2007	April,2008	Oct.2008
27	January, 2007	July,2008	May,2010
28	March, 2007	March,2009	March, 2010
29	April,2007	April,2009	March, 2010

30	June,2008	Nov.2009	July, 2010
31	Sep,2006	March, 2008	Sep,2008
32	Sep,2008	Aug,2010	March, 2010
33	Sep,2008	Aug,2010	March, 2010
34	Oct, 2005	March, 2007	Dec, 2008
35	June,2009	March,2011	March, 2011
36	Feb, 2005	August, 2006	April, 2008
37	July,2005	July,2007	Dec,2007
38	July,2004	March,2005	June, 2005
39	Jan, 2005	Jan,2007	August, 2007
40	July, 2006	June, 2008	June, 2010
41	June, 2008	Aug, 2010	Nov, 2010
42	June,2006	Nov,2008	Sep,2009
43	August,2007	August,2008	May,2010
44	2005	2008	2010
45			
46	August, 2005	Sep, 2008	August, 2010
47	Dec, 2007	Sep, 2008	Nov, 2010
48	Feb, 2009	Aug, 2009	June, 2010
49	Aug,2008	Dec,2010	January, 2011
50	March, 2007	Feb,2008	Feb,2008
51	April, 2009	March, 2010	March, 2010
52	Feb, 2004	Oct, 2005	Dec, 2005
53	May, 2005	June, 2007	Oct, 2008
54	Feb, 2009	Dec, 2009	Feb,2010
55	July, 2005	June, 2007	January, 2008
56	March, 2004	Sep, 2005	Aug, 2006
57			
58	April, 2010	Dec, 2010	March, 2011
59	March, 2005	Jan, 2006	March, 2006
60	July, 2007	Sep, 2010	Sep, 2010

61	March, 2010	March, 2011	March, 2011
62	May, 2007	Nov, 2008	June, 2009
63	Oct, 2006	June,2007	June, 2008
64	Jan, 2008	Dec, 2008	Jan, 2009
65	Sep, 2005	Sep, 2006	July, 2007
66	August, 2005	April, 2006	July, 2007
67	August, 2005	April, 2006	July, 2007
68	Feb, 2007	Feb, 2008	July, 2009
69	Dec,2007	August, 2008	Dec, 2008
70	March, 2006	March, 2007	June, 2007
71	March, 2009	Dec, 2009	March, 2010
72	Dec,2006	August, 2008	Feb, 2009
73	Oct,2010	Dec, 2010	Jan, 2011
74	May, 2007	Dec, 2008	Nov, 2010
75	May, 2007	Dec, 2008	Dec, 2010
76	March, 2008	Sep, 2009	Feb, 2011
77	May, 2008	Nov, 2009	March, 2011
78	Jan,2007	October, 2010	March, 2011
79	April, 2009		April, 2010
80	April, 2009		March, 2010
81	Feb, 2008		Jan, 2011
84	June, 2005	2008	March, 2011
85	August, 2005	2008	Feb, 2011
86	oct, 2005	2008	Jan, 2011
87	June, 2008	Dec, 2008	Dec, 2010
88	June, 2008	June, 2010	Feb, 2011
89	May, 2009	Feb, 2010	May,2010
90	Sep, 2009	March, 2011	March, 2011
91	Jan, 2006	Sep, 2006	Oct, 2007
92	June, 2007	Dec, 2008	Augest, 2009

Project #	Proposed Completion Time *(Months)*	Actual Completion Time *(Months)*	Schedule Growth (%)	Construction Speed *(ft^2/month)*
1	15	50	233.33	4950
2	18	41	127.78	3002.93
3	12	56	366.67	3908.57
4	12	55	358.33	3520
5	15	41	173.33	5031.22
6	15	45	200	3333.33
7	15	45	200	2666.67
8	9	21	133.33	1695.24
9	9	21	133.33	2145.52
10	9	34	277.78	914.71
11	9	32	255.56	548.13
12	9	32	255.56	968.13
13	9	33	266.67	634.55
14	9	17	88.89	1589.18
15	8	18	125	1043.44
16	12	26	116.67	3780
17	12	19	58.33	2298.95
18	12	19	58.33	18421.05
19	8	8	0	6325
20	12	12	0	4333.33
21	21	40	90.48	2337.5
22	16	31	93.75	4275.77
23	19	29	52.63	4689.28
24	16	22	37.5	4005.82
25	21	39	85.71	2859.87
26	14	20	42.86	2425.05
27	18	40	122.22	1993.2
28	24	36	50	2121.92
29	24	35	45.83	1723.23
30	17	25	47.06	3787.92
31	18	24	33.33	2636.25
32	23	18	-21.74	4549.39
33	23	18	-21.74	3640.28
34	17	38	123.53	1933.18
35	21	21	0	10330.24
36	18	38	111.11	2461.18
37	24	29	20.83	586.21
38	9	11	22.22	363.64
39	24	31	29.17	2806.45
40	23	48	108.7	2979.17
41	26	29	11.54	1241.38

42	29	39	34.48	1442.62
43	12	33	175	9646.06
44	36	60	66.67	50000
45				
46	36	60	66.67	75000
47	9	35	288.89	2134.94
48	6	16	166.67	9511.5
49	28	29	3.57	1034.48
50	11	11	0	2000
51	11	11	0	218.18
52	20	22	10	2727.27
53	25	41	64	1097.56
54	10	12	20	416.67
55	23	30	30.43	833.33
56	18	29	61.11	1655.17
57	10	10	0	9000
58	9	12	33.33	4166.67
59	10	12	20	13333.33
60	38	38	0	2665.79
61	12	12	0	20833.33
62	18	25	38.89	5120
63	8	20	150	12250
64	12	13	8.33	1096.92
65	12	22	83.33	10456.27
66	8	23	187.5	1768.3
67	8	23	187.5	1426.13
68	12	29	141.67	475.59
69	8	12	50	1592.83
70	12	15	25	4384.87
71	9	12	33.33	4226.58
72	21	27	28.57	2667.33
73	3	4	33.33	1114.75
74	19	42	121.05	5865.86
75	19	43	126.32	5877.61
76	18	35	94.44	5026.63
77	18	34	88.89	6757.56
78	45	50	11.11	8094.52
79	8	9	12.5	250
80	10	10	0	329.85
81	18	33	83.33	6340.91
82	18	32	77.78	9360.13
83	24	36	50	8227.5
84	35	64	82.86	371.34
85	33	67	103.03	185.07
86	34	66	94.12	250.53

87	6	30	400	145
88	24	32	33.33	1437.5
89	9	12	33.33	923.67
90	18	18	0	11666.67
91	9	22	144.44	3840.91
92	18	26	44.44	1305.65

Project #	Certainty of completion on contract price	Certainty of completion on time
1	Within 5% of contract price	Over ran by more than 5%
2	Within 5% of contract price	Over ran by more than 5%
3	Within 5% of contract price	Over ran by more than 5%
4	Within 5% of contract price	Over ran by more than 5%
5	Over ran by more than 5%	Over ran by more than 5%
6	Within 5% of contract price	Over ran by more than 5%
7	Within 5% of contract price	Over ran by more than 5%
8	Over ran by more than 5%	Over ran by more than 5%
9	Over ran by more than 5%	Over ran by more than 5%
10	Over ran by more than 5%	Over ran by more than 5%
11	Over ran by more than 5%	Over ran by more than 5%
12	Over ran by more than 5%	Over ran by more than 5%
13	Over ran by more than 5%	Over ran by more than 5%
14	Over ran by more than 5%	Over ran by more than 5%
15	Within 5% of contract price	Over ran by more than 5%
16	Over ran by more than 5%	Over ran by more than 5%
17	Over ran by more than 5%	Over ran by more than 5%
18	Over ran by more than 5%	Over ran by more than 5%
19	Over ran by more than 5%	Within 5% of planned schedule duration
20	Over ran by more than 5%	Within 5% of planned schedule duration
21	Over ran by more than 5%	Over ran by more than 5%
22	Over ran by more than 5%	Over ran by more than 5%
23	Over ran by more than 5%	Over ran by more than 5%
24	Over ran by more than 5%	Over ran by more than 5%
25	Over ran by more than 5%	Over ran by more than 5%
26	Over ran by more than 5%	Over ran by more than 5%
27	Over ran by more than 5%	Over ran by more than 5%
28	Within 5% of contract price	Over ran by more than 5%
29	Over ran by more than 5%	Over ran by more than 5%
30	Over ran by more than 5%	Over ran by more than 5%
31	Over ran by more than 5%	Over ran by more than 5%
32	Within 5% of contract price	Within 5% of planned schedule duration
33	Within 5% of contract price	Within 5% of planned schedule duration
34	Over ran by more than 5%	Over ran by more than 5%
35	Over ran by more than 5%	Within 5% of planned schedule duration
36	Over ran by more than 5%	Over ran by more than 5%
37	Over ran by more than 5%	Over ran by more than 5%
38	Over ran by more than 5%	Over ran by more than 5%
39	Within 5% of contract price	Over ran by more than 5%
40	Within 5% of contract price	Over ran by more than 5%
41	Under ran by more than 5%	Over ran by more than 5%

42	Over ran by more than 5%	Over ran by more than 5%
43	Over ran by more than 5%	Over ran by more than 5%
44	Over ran by more than 5%	Over ran by more than 5%
45	Over ran by more than 5%	
46	Over ran by more than 5%	Over ran by more than 5%
47	Under ran by more than 5%	Over ran by more than 5%
48	Over ran by more than 5%	Over ran by more than 5%
49	Over ran by more than 5%	Within 5% of planned schedule duration
50	Within 5% of contract price	Within 5% of planned schedule duration
51	Within 5% of contract price	Within 5% of planned schedule duration
52	Over ran by more than 5%	Over ran by more than 5%
53	Over ran by more than 5%	Over ran by more than 5%
54	Within 5% of contract price	Over ran by more than 5%
55	Within 5% of contract price	Over ran by more than 5%
56	Over ran by more than 5%	Over ran by more than 5%
57	Over ran by more than 5%	Within 5% of planned schedule duration
58	Over ran by more than 5%	Over ran by more than 5%
59	Over ran by more than 5%	Over ran by more than 5%
60	Within 5% of contract price	Within 5% of planned schedule duration
61	Within 5% of contract price	Within 5% of planned schedule duration
62	Within 5% of contract price	Over ran by more than 5%
63	Over ran by more than 5%	Over ran by more than 5%
64	Over ran by more than 5%	Within 5% of planned schedule duration
65	Over ran by more than 5%	Over ran by more than 5%
66	Within 5% of contract price	Over ran by more than 5%
67	Within 5% of contract price	Over ran by more than 5%
68	Over ran by more than 5%	Over ran by more than 5%
69	Within 5% of contract price	Over ran by more than 5%
70	Under ran by more than 5%	Over ran by more than 5%
71	Within 5% of contract price	Over ran by more than 5%
72	Within 5% of contract price	Over ran by more than 5%
73	Within 5% of contract price	Within 5% of planned schedule duration
74	Over ran by more than 5%	Over ran by more than 5%
75	Over ran by more than 5%	Over ran by more than 5%
76	Over ran by more than 5%	Over ran by more than 5%
77	Over ran by more than 5%	Over ran by more than 5%
78	Over ran by more than 5%	Over ran by more than 5%
79	Within 5% of contract price	Within 5% of planned schedule duration
80	Within 5% of contract price	Within 5% of planned schedule duration
81	Over ran by more than 5%	Over ran by more than 5%
82	Over ran by more than 5%	Over ran by more than 5%
83	Over ran by more than 5%	Over ran by more than 5%
84	Over ran by more than 5%	Over ran by more than 5%
85	Over ran by more than 5%	Over ran by more than 5%
86	Over ran by more than 5%	Over ran by more than 5%

87	Over ran by more than 5%	Over ran by more than 5%
88	Over ran by more than 5%	Over ran by more than 5%
89	Within 5% of contract price	Over ran by more than 5%
90	Within 5% of contract price	Within 5% of planned schedule duration
91	Within 5% of contract price	Over ran by more than 5%
92	Within 5% of contract price	Over ran by more than 5%

Project #	Project Client	Project Type	Project Delivery Method
1	Public	Residential Building	Design-Bid-Build
2	Public	Residential Building	Design-Bid-Build
3	Public	Residential Building	Design-Bid-Build
4	Public	Residential Building	Design-Bid-Build
5	Public	Residential Building	Design-Bid-Build
6	Public	Residential Building	Design-Bid-Build
7	Public	Residential Building	Design-Bid-Build
8	Public	Public Service Building	Design-Bid-Build
9	Public	Public Service Building	Design-Bid-Build
10	Public	Public Service Building	Design-Bid-Build
11	Public	Public Service Building	Design-Bid-Build
12	Public	Public Service Building	Design-Bid-Build
13	Public	Public Service Building	Design-Bid-Build
14	Public	Public Service Building	Design-Bid-Build
15	Public	Public Service Building	Design-Bid-Build
16	Public	Residential Building	Design-Bid-Build
17	Public	Residential Building	Design-Bid-Build
18	Private	Other	Design-Bid-Build
19	Private	Public Service Building	Design-Bid-Build
20	Private	Public Service Building	Design-Bid-Build
21	Public	Public Service Building	Design-Bid-Build
22	Public	Residential Building	Design-Bid-Build
23	Public	Residential Building	Design-Bid-Build
24	Public	Public Service Building	Design-Bid-Build
25	Public	Public Service Building	Design-Bid-Build
26	Public	Public Service Building	Design-Bid-Build
27	Public	Residential Building	Design-Bid-Build
28	Public	Residential Building	Design-Bid-Build
29	Public	Residential Building	Design-Bid-Build
30	Public	Residential Building	Design-Bid-Build
31	Public	Public Service Building	Design-Bid-Build
32	Public	Public Service Building	Design-Bid-Build
33	Public	Public Service Building	Design-Bid-Build
34	Public	Public Service Building	Design-Bid-Build
35	Private	Residential Building	Design-Bid-Build
36	Public	Public Service Building	Design-Bid-Build
37	Private	Public Service Building	Design-Bid-Build
38	Private	Public Service Building	Design-Bid-Build
39	Public	Public Service Building	Design-Bid-Build
40	Public	Public Service Building	Design-Bid-Build
41	Private	Commercial Building	Design-Bid-Build

42	Private	Commercial Building	Design-Bid-Build
43	Public	Residential Building	Design-Bid-Build
44	Private	Residential Building	Design-Bid-Build
45	Public	Residential Building	Design-Bid-Build
46	Public	Public Service Building	Design-Bid-Build
47	Public	Public Service Building	Design-Build
48	Public	Public Service Building	Design-Build
49	Private	Commercial Building	Design-Build
50	Private	Public Service Building	Design-Build
51	Private	Residential Building	Design-Build
52	Private	Public Service Building	Design-Build
53	Private	Commercial Building	Design-Build
54	Private	Residential Building	Design-Build
55	Private	Residential Building	Design-Build
56	Private	Public Service Building	Design-Build
57	Private	Other	Design-Build
58	Private	Other	Design-Build
59	Private	Other	Design-Build
60	Public	Residential Building	Design-Build
61	Private	Other	Design-Build
62	Private	Commercial Building	Design-Build
63	Private	Other	Design-Build
64	Public	Public Service Building	Design-Build
65	Public	Public Service Building	Design-Build
66	Public	Residential Building	Design-Build
67	Public	Residential Building	Design-Build
68	Public	Public Service Building	Design-Build
69	Public	Public Service Building	Design-Build
70	Public	Public Service Building	Design-Build
71	Public	Public Service Building	Design-Build
72	Public	Public Service Building	Design-Build
73	Public	Public Service Building	Design-Build
74	Private	Residential Building	Design-Build
75	Private	Residential Building	Design-Build
76	Private	Residential Building	Design-Build
77	Private	Residential Building	Design-Build
78	Public	Commercial Building	Design-Build
79	Private	Residential Building	Design-Build
80	Private	Residential Building	Design-Build
81	Private	Residential Building	Design-Build
82	Private	Residential Building	Design-Build
83	Private	Residential Building	Design-Build
84	Private	Commercial Building	Design-Build
85	Private	Residential Building	Design-Build
86	Private	Commercial Building	Design-Build

87	Public	Public Service Building	Design-Build
88	Public	Public Service Building	Design-Build
89	Public	Public Service Building	Design-Build
90	Public	Public Service Building	Design-Build
91	Public	Public Service Building	Design-Build
92	Public	Public Service Building	Design-Build

Project #	Pre-Qualification	Contractor Selection	Procedure for Open Competitive Bidding	Lowest Bidder
1	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
2	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
3	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
4	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
5	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
6	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
7	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
8	No	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
9	No	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
10	No	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
11	No	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
12	No	Negotiated Tendering	-	No
13	No	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
14	No	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
15	No	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
16	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
17	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
18	Yes	Negotiated Tendering	-	Yes
19	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
20	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
21	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
22	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
23	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes

24	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
25	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
26	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
27	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
28	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
29	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
30	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
31	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
32	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
33	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
34	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
35	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
36	Yes	Open Competitive Bidding	Single stage- Two envelope procedure	Yes
37	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
38	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
39	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
40	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
41	No	Open Competitive Bidding	-	No
42	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
43	Yes	Open Competitive Bidding	Single stage- Two envelope procedure	Yes
44	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
45	No	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
46	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
47	No	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
48	No	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
49	No	Negotiated	-	No

		Tendering		
50	No	Negotiated Tendering	-	No
51	No	Negotiated Tendering	-	No
52	No	Negotiated Tendering	-	No
53	No	Negotiated Tendering	-	No
54	No	Negotiated Tendering	-	No
55	No	Negotiated Tendering	-	No
56	No	Negotiated Tendering	-	No
57	No	Negotiated Tendering	-	No
58	No	Negotiated Tendering	-	Yes
59	No	Negotiated Tendering	-	No
60	No	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
61	No	Negotiated Tendering	-	Yes
62	Yes	Negotiated Tendering	-	No
63	No	Negotiated Tendering	-	Yes
64	No	Open Competitive Bidding	Single stage- Two envelope procedure	Yes
65	Yes	Open Competitive Bidding	Single stage- Two envelope procedure	Yes
66	Yes	Open Competitive Bidding	Single stage- Two envelope procedure	Yes
67	Yes	Open Competitive Bidding	Single stage- Two envelope procedure	Yes
68	Yes	Open Competitive Bidding	Single stage- Two envelope procedure	Yes
69	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
70	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
71	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	-
72	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	-
73	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	-
74	Yes	Open Competitive Bidding	Single stage- Two envelope procedure	No

75	Yes	Open Competitive Bidding	Single stage- Two envelope procedure	No
76	Yes	Open Competitive Bidding	Single stage- Two envelope procedure	No
77	Yes	Open Competitive Bidding	Single stage- Two envelope procedure	No
78	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
79	-	-	-	-
80	-	-	-	-
81	No	Negotiated Tendering	-	No
82	No	Negotiated Tendering	-	No
83	No	Negotiated Tendering	-	No
84	No	Negotiated Tendering	-	No
85	No	Negotiated Tendering	-	No
86	No	Negotiated Tendering	-	No
87	No	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
88	No	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
89	No	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
90	Yes	Open Competitive Bidding	Single stage- Two envelope procedure	Yes
91	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes
92	Yes	Open Competitive Bidding	Single Stage- One envelope procedure	Yes

Project #	Construction Contract Type	Design Completion	Disputes	Disputes Settlement
1	Other	90-100%	Yes	Amicable Settlement
2	Other	90-100%	Yes	Amicable Settlement
3	Other	90-100%	Yes	Amicable Settlement
4	Other	90-100%	Yes	Amicable Settlement
5	Other	90-100%	Yes	Amicable Settlement
6	Other	90-100%	Yes	Amicable Settlement
7	Other	90-100%	No	-
8	Unit Price	90-100%	No	-
9	Unit Price	90-100%	No	-
10	Unit Price	90-100%	Yes	Engineers Decision
11	Unit Price	90-100%	No	-
12	Unit Price	90-100%	No	-
13	Unit Price	90-100%	No	-
14	Unit Price	90-100%	No	-
15	Unit Price	90-100%	No	-
16	Lump sum	90-100%	No	-
17	Lump sum	90-100%	No	-
18	Unit Price	90-100%	No	-
19	Unit Price	90-100%	No	-
20	Unit Price	90-100%	No	-
21	Unit Price	90-100%	No	-
22	Unit Price	90-100%	No	-
23	Unit Price	90-100%	No	-
24	Unit Price	90-100%	No	-
25	Unit Price	90-100%	No	-
26	Unit Price	90-100%	No	-
27	Unit Price	90-100%	No	-
28	Unit Price	90-100%	No	-
29	Unit Price	90-100%	No	-
30	Unit Price	90-100%	No	-
31	Unit Price	90-100%	No	-
32	Unit Price	90-100%	No	-
33	Unit Price	90-100%	No	-
34	Schedule Price	90-100%	Yes	Engineers Decision
35	Lump sum	90-100%	Yes	Engineers Decision
36	Unit Price	90-100%	No	-
37	Unit Price	90-100%	Yes	Engineers Decision
38	Unit Price	90-100%	No	-
39	Schedule Price	90-100%	Yes	Engineers Decision
40	Unit Price	90-100%	No	-
41	Unit Price	90-100%	No	-

42	Unit Price	90-100%	Yes	Amicable Settlement
43	Lump sum	90-100%	No	-
44	Lump sum	90-100%	Yes	Engineers Decision
45	Schedule Price	90-100%	Yes	Engineers Decision
46	Unit Price	90-100%	Yes	Amicable Settlement
47	Lump sum	90-100%	No	-
48	Unit Price	50-70%	No	-
49	Schedule Price	0-30%	No	-
50	Schedule Price	0-30%	No	-
51	Schedule Price	0-30%	No	-
52	Schedule Price	0-30%	No	-
53	Schedule Price	0-30%	No	-
54	Schedule Price	0-30%	No	-
55	Schedule Price	0-30%	No	-
56	Schedule Price	0-30%	Yes	Amicable Settlement
57	Unit Price	0-30%	Yes	Amicable Settlement
58	Unit Price	0-30%	No	-
59	Unit Price	0-30%	No	-
60	Schedule Price	90-100%	Yes	Engineers Decision
61	Unit Price	0-30%	No	-
62	Unit Price	0-30%	No	-
63	Unit Price	0-30%	No	-
64	Schedule Price	90-100%	No	-
65	Schedule Price	90-100%	No	-
66	Schedule Price	90-100%	No	-
67	Schedule Price	90-100%	No	-
68	Schedule Price	90-100%	No	-
69	Schedule Price	90-100%	No	-
70	Schedule Price	90-100%	No	-
71	Schedule Price	90-100%	No	-
72	Schedule Price	90-100%	No	-
73	Schedule Price	90-100%	No	-
74	Lump sum	70-90%	Yes	Engineers Decision
75	Lump sum	50-70%	Yes	Engineers Decision
76	Lump sum	50-70%	Yes	Engineers Decision
77	Lump sum	70-90%	Yes	Engineers Decision
78	Other	30-50%	No	-
79	Unit Price	70-90%	-	-
80	Unit Price	70-90%	-	-
81	Other	50-70%	Yes	Amicable Settlement
82	Other	50-70%	Yes	Amicable Settlement
83	Other	50-70%	Yes	Amicable Settlement
84	Unit Price	30-50%	No	-
85	Unit Price	50-70%	No	-
86	Unit Price	30-50%	No	-

87	Schedule Price	90-100%	Yes	Engineers Decision
88	Schedule Price	90-100%	Yes	Engineers Decision
89	Schedule Price	90-100%	Yes	Engineers Decision
90	Lump sum	30-50%	No	-
91	Unit Price	70-90%	Yes	Amicable Settlement
92	Schedule Price	0-30%	No	-

Project #	General Condition of Contract	Incentive Clause	Liquidated Damage Clause	Escalation Clause
1	FIDIC	No	Yes	Yes
2	FIDIC	No	Yes	Yes
3	FIDIC	No	Yes	Yes
4	FIDIC	No	Yes	Yes
5	FIDIC	No	Yes	Yes
6	FIDIC	No	Yes	Yes
7	FIDIC	No	Yes	Yes
8	Departmental conditions of contract	Yes	Yes	Yes
9	Departmental conditions of contract	Yes	Yes	Yes
10	Departmental conditions of contract	Yes	Yes	Yes
11	Departmental conditions of contract	Yes	Yes	Yes
12	Departmental conditions of contract	Yes	Yes	Yes
13	Departmental conditions of contract	Yes	Yes	Yes
14	Departmental conditions of contract	Yes	Yes	Yes
15	Departmental conditions of contract	Yes	Yes	Yes
16	FIDIC	Yes	Yes	Yes
17	FIDIC	Yes	Yes	Yes
18	PEC Standard format of contract	No	No	Yes
19	Departmental conditions of contract	No	No	No
20	Departmental conditions of contract	No	No	No
21	FIDIC	No	Yes	Yes
22	FIDIC	No	Yes	Yes
23	FIDIC	No	Yes	Yes
24	FIDIC	No	Yes	Yes
25	FIDIC	No	Yes	Yes
26	FIDIC	No	Yes	Yes
27	FIDIC	No	Yes	Yes
28	FIDIC	No	Yes	Yes
29	FIDIC	No	Yes	Yes
30	FIDIC	No	Yes	Yes
31	FIDIC	No	Yes	Yes
32	FIDIC	No	Yes	Yes
33	FIDIC	No	Yes	Yes
34	Departmental conditions of contract	No	No	Yes
35	Departmental conditions of contract	No	Yes	No
36	Departmental conditions of contract	No	Yes	No
37	PEC Standard format of contract	No	Yes	Yes
38	PEC Standard format of contract	No	Yes	Yes
39	PEC Standard format of contract	No	No	No
40	FIDIC	Yes	Yes	Yes
41	PEC Standard format of contract	No	No	No

42	PEC Standard format of contract	No	Yes	Yes
43	FIDIC	Yes	Yes	Yes
44	PEC Standard format of contract	No	No	Yes
45	Departmental conditions of contract	No	No	No
46	Departmental conditions of contract	No	No	Yes
47	Departmental conditions of contract	Yes	Yes	Yes
48	Departmental conditions of contract	Yes	Yes	Yes
49	Departmental conditions of contract	No	No	No
50	Departmental conditions of contract	No	No	No
51	Departmental conditions of contract	No	No	No
52	Departmental conditions of contract	No	No	No
53	Departmental conditions of contract	No	No	No
54	Departmental conditions of contract	No	No	No
55	Departmental conditions of contract	No	No	No
56	Departmental conditions of contract	No	No	No
57	Departmental conditions of contract	Yes	No	Yes
58	PEC Standard format of contract	No	No	No
59	PEC Standard format of contract	No	No	No
60	Departmental conditions of contract	No	No	Yes
61	FIDIC	No	Yes	No
62	FIDIC	No	Yes	No
63	FIDIC	No	Yes	No
64	Departmental conditions of contract	Yes	No	Yes
65	Departmental conditions of contract	Yes	No	Yes
66	Departmental conditions of contract	Yes	No	Yes
67	Departmental conditions of contract	Yes	No	Yes
68	Departmental conditions of contract	Yes	No	Yes
69	Departmental conditions of contract	No	No	Yes
70	Departmental conditions of contract	No	No	Yes
71	Departmental conditions of contract	No	No	Yes
72	Departmental conditions of contract	No	No	Yes
73	Departmental conditions of contract	No	No	Yes
74	Departmental conditions of contract	No	Yes	No
75	Departmental conditions of contract	No	Yes	No
76	Departmental conditions of contract	No	Yes	No
77	Departmental conditions of contract	No	Yes	No
78	Departmental conditions of contract	No	Yes	Yes
79	Departmental conditions of contract			
80	Departmental conditions of contract			
81	Departmental conditions of contract	Yes	Yes	Yes
82	Departmental conditions of contract	Yes	Yes	Yes
83	Departmental conditions of contract	Yes	Yes	Yes
84	Departmental conditions of contract	No	Yes	Yes
85	Departmental conditions of contract	No	Yes	Yes
86	Departmental conditions of contract	No	Yes	Yes

87	Departmental conditions of contract	No	No	No
88	Departmental conditions of contract	No	No	No
89	Departmental conditions of contract	No	No	No
90	FIDIC	Yes	Yes	Yes
91	PEC Standard format of contract	No	No	Yes
92	Departmental conditions of contract	No	No	Yes

APPENDIX III

CODIFICATION OF VARIABLES

Label	Values
Year of Completion	1= "2006" 2= "2007" 3= "2008" 4= "2009" 5= "2010" 6= "2011"
Certainty of completion on contract price	1= "Over ran by more than 5%" 2= "Within 5% of Contract Price" 3= "Under ran by more than 5%"
Certainty of completion on time	1= "Over ran by more than 5%" 2= "Within 5% of Planned Schedule Duration" 3= "Under ran by more than 5%"
Project Client	1= "Public" 2= "Private"
Project Type	1= "Residential Building 2= "Commercial Building" 3= "Public Service Building" 4= "Other"
Project Delivery Method	1= "Design-Bid-Build" 2= "Design-Build"
Pre Qualification of Contractors	1= "YES" 2= "NO"
Contractor Selection	1= "Open competitive bidding/tendering" 2= "Negotiated Tendering"
Procedure for open competitive bidding	1= "Single stage – one envelope procedure" 2= "Single stage – two envelope procedure"

	3= “Two stage bidding procedure” 4= “Two stage - two envelope procedure”
Lowest bidder	1= “YES” 2= “NO”
Construction Contract Type	1= “Lump Sum” 2= “Unit Price ” 3= “Schedule Price” 4= “Other
Design completion	1= “0-30%” 2= “30-50%” 3= “50-70%” 4= “70-90” 5= “90-100%”
Disputes	1= “YES” 2= “NO”
Dispute Settlement	1= “Engineer’s Decision” 2= “Amicable Settlement” 3= “Arbitration”
Condition of Contract	1= “FIDIC” 2= “PEC Standard format of Contract ” 3= “Departmental Conditions of Contract ”
Incentive Clause	1= “YES” 2= “NO”
Liquidated Damages Clause	1= “YES” 2= “NO”
Escalation Clause	1= “YES” 2= “NO”

Project #	Project Name	Year of Completion	Completion on contract Cost	Completion on proposed schedule
1	FGEHF Package 1	1	2	1
2	Package 2	3	2	1
3	Package 3	1	2	1
4	Package 4	1	2	1
5	Package 5	2	1	1
6	Package 6	1	2	1
7	Package 7	1	2	1
8	CP-3 (LOT-2)	3	1	1
9	CP-3 (LOT-3)	3	1	1
10	CP-4 (LOT-1)	2	1	1
11	CP-4 (LOT-2)	2	1	1
12	CP-4 (LOT-4)	2	1	1
13	CP-4 (LOT-5)	2	1	1
14	CP-2A (LOT-5)	2	1	1
15	CP-2A (LOT-6)	2	2	1
16	PHA Construction of D Type Apartment, Isb.	2	1	1
17	PHA Construction of E Type Apartment	3	1	1
18	PEL Transformer Unit II	3	1	1
19	Aitchison School, Lhr	2	1	2
20	Aitchison School, Lhr	2	1	2
21	NBS (NIMS), NUST, Isb.	4	1	1
22	Hostel Pkg-I	4	1	1
23	Hostel Pkg-II	4	1	1
24	NIT & IESE	4	1	1
25	SEECS (NIIT)	4	1	1
26	CCE&MS (SCME)	4	1	1
27	Staff Res Pkg-I	2	1	1
28	Staff Res Pkg-II	2	2	1
29	Staff Pkg III	2	1	1
30	Hostel Pkg-III	2	1	1
31	IGIS, RIMMS & RCMS	4	1	1
32	IAEC, IT & CCT&SM	2	2	2
33	IME & DOR	2	2	2
34	Population House, Isb	4	1	1
35	Alma Townhouses, Isb	1	1	2
36	PNRA HQ Building, Isb.	4	1	1
37	Islamabad Club (Multipurpose Hall)	5	1	1
38	Club Arcade	6	1	1

39	LG & RD, Isb	5	2	1
40	NBP, Isb	2	2	1
41	IT Tower, Lhr	2	3	1
42	Islamabad Stock Exchange Tower	3	1	1
43	PHA Construction of C Type Apartment	2	1	1
44	Creek City 12 Towers DHA, Karachi	2	1	1
45	Residential Accommodation of FG Employee, Isb.	1	1	
46	University of Gujarat	2	1	1
47	CP (1) Earthquake Additional Financing Project	2	3	1
48	CP-7	2	1	1
49	Bahria Guest House/ Hotel, Lhr.	1	1	2
50	Telephone Exchange	4	2	2
51	Safari Villas	2	2	2
52	Bahria School	6	1	1
53	Multi Mart	4	1	1
54	Houses Meadows	2	2	1
55	Safari Mall	4	2	1
56	Bahria Hospital	6	1	1
57	NIPPON Paints Project	2	1	2
58	NISHAT Apparel	1	1	1
59	PAPER SACK Plant	6	1	1
60	Construction of 48 Family Suites, Isb	2	2	2
61	Dada Dairy, Lhr	1	2	2
62	Din Commercial Building, Lhr.	2	2	1
63	Premium Lather Factory, Lhr.	4	1	1
64	Development of Wheat Analytical Lab, Fsd.	3	1	2
65	Establishment of Main Building, Fsd.	5	1	1
66	Establishment of Doctors Hospital	5	2	1
67	Establishment of Nursing Hospital	5	2	1
68	Construction of Judicial Complex	3	1	1
69	LDA Model school, Lhr.	4	2	1
70	LDA Office Building	5	3	1
71	LDA Office Building	2	2	1
72	LDA Model school	3	2	1

73	Building Hall @LDA	1	2	2
74	Mirador Villas 1, Isb.	2	1	1
75	Mirador Villas 2, Isb.	2	1	1
76	Mirador Villas 3, Isb.	1	1	1
77	Mirador Villas 4, Isb.	1	1	1
78	Const. of Local Centre DHA, Isb.	1	1	1
79	Dream Villas Lux. 5 Marla, Lhr.	2	2	2
80	Dream Villas Lux 7 Marla	2	2	2
81	Eden Builders 10 Marla, Lhr.	1	1	1
82	Eden Builders 7 Marla	2	1	1
83	Eden Builders 3.5 Marla	1	1	1
84	Main Club Building DHA, Isb.	1	1	1
85	Family Wing DHA, Isb.	1	1	1
86	Administration Block DHA, Isb.	1	1	1
87	Construction of Mosque at PM Sec. Isb.	2	1	1
88	Construction of 12 Apartments for FMR, Isb.	1	1	1
89	Construction of Classrooms & Admin Block, Isb	2	2	1
90	Forensic Science Lab, Lhr.	1	2	2
91	VIP Hanger @ Old Terminal, Lhr.	5	2	1
92	Establishment of Drug Rehabilitation Centre, Multan	3	2	1

Project #	Project Client	Project Type	Project Delivery Method	Construction Contract Type	Design Completion
1	1	1	1	4	5
2	1	1	1	4	5
3	1	1	1	4	5
4	1	1	1	4	5
5	1	1	1	4	5
6	1	1	1	4	5
7	1	1	1	4	5
8	1	3	1	2	5
9	1	3	1	2	5
10	1	3	1	2	5
11	1	3	1	2	5
12	1	3	1	2	5
13	1	3	1	2	5
14	1	3	1	2	5
15	1	3	1	2	5
16	1	1	1	1	5
17	1	1	1	1	5
18	2	4	1	2	5
19	2	3	1	2	5
20	2	3	1	2	5
21	1	3	1	2	5
22	1	1	1	2	5
23	1	1	1	2	5
24	1	3	1	2	5
25	1	3	1	2	5
26	1	3	1	2	5
27	1	1	1	2	5
28	1	1	1	2	5
29	1	1	1	2	5
30	1	1	1	2	5
31	1	3	1	2	5
32	1	3	1	2	5
33	1	3	1	2	5
34	1	3	1	3	5
35	2	1	1	1	5
36	1	3	1	2	5
37	2	3	1	2	5
38	2	3	1	2	5
39	1	3	1	3	5
40	1	3	1	2	5
41	2	2	1	2	5

42	2	2	1	2	5
43	1	1	1	1	5
44	2	1	1	1	5
45	1	1	1	3	5
46	1	3	1	2	5
47	1	3	2	1	5
48	1	3	2	2	3
49	2	2	2	3	1
50	2	3	2	3	1
51	2	1	2	3	1
52	2	3	2	3	1
53	2	2	2	3	1
54	2	1	2	3	1
55	2	1	2	3	1
56	2	3	2	3	1
57	2	4	2	2	1
58	2	4	2	2	1
59	2	4	2	2	1
60	1	1	2	3	5
61	2	4	2	2	1
62	2	2	2	2	1
63	2	4	2	2	1
64	1	3	2	3	5
65	1	3	2	3	5
66	1	1	2	3	5
67	1	1	2	3	5
68	1	3	2	3	5
69	1	3	2	3	5
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72	1	3	2	3	5
73	1	3	2	3	5
74	2	1	2	1	4
75	2	1	2	1	3
76	2	1	2	1	3
77	2	1	2	1	4
78	1	2	2	4	2
79	2	1	2	2	4
80	2	1	2	2	4
81	2	1	2	4	3
82	2	1	2	4	3
83	2	1	2	4	3
84	2	2	2	2	2
85	2	1	2	2	3
86	2	2	2	2	2

87	1	3	2	3	5
88	1	3	2	3	5
89	1	3	2	3	5
90	1	3	2	1	2
91	1	3	2	2	4
92	1	3	2	3	1

Project #	Pre-Qualification	Contractor Selection	Procedure for Open Competitive Bidding	Lowest Bidder	Disputes	Disputes Settlement
1	1	1	1	1	1	2
2	1	1	1	1	1	2
3	1	1	1	1	1	2
4	1	1	1	1	1	2
5	1	1	1	1	1	2
6	1	1	1	1	1	2
7	1	1	1	1	2	-
8	2	1	1	1	2	-
9	2	1	1	1	2	-
10	2	1	1	1	1	1
11	2	1	1	1	2	-
12	2	2	-	2	2	-
13	2	1	1	1	2	-
14	2	1	1	1	2	-
15	2	1	1	1	2	-
16	1	1	1	1	2	-
17	1	1	1	1	2	-
18	1	2	-	1	2	-
19	1	1	1	1	2	-
20	1	1	1	1	2	-
21	1	1	1	1	2	-
22	1	1	1	1	2	-
23	1	1	1	1	2	-
24	1	1	1	1	2	-
25	1	1	1	1	2	-
26	1	1	1	1	2	-
27	1	1	1	1	2	-
28	1	1	1	1	2	-
29	1	1	1	1	2	-
30	1	1	1	1	2	-
31	1	1	1	1	2	-
32	1	1	1	1	2	-
33	1	1	1	1	2	-
34	1	1	1	1	1	1
35	1	1	1	1	1	1
36	1	1	2	1	2	-
37	1	1	1	1	1	1
38	1	1	1	1	2	-
39	1	1	1	1	1	1
40	1	1	1	1	2	-
41	2	1	-	2	2	-

42	1	1	1	1	1	2
43	1	1	2	1	2	
44	1	1	1	1	1	1
45	2	1	1	1	1	1
46	1	1	1	1	1	2
47	2	1	1	1	2	
48	2	1	1	1	2	
49	2	2	-	2	2	
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55	2	2	-	2	2	
56	2	2	-	2	1	2
57	2	2	-	2	1	2
58	2	2	-	1	2	-
59	2	2	-	2	2	-
60	2	1	1	1	1	1
61	2	2	-	1	2	-
62	1	2	-	2	2	-
63	2	2	-	1	2	-
64	2	1	2	1	2	-
65	1	1	2	1	2	-
66	1	1	2	1	2	-
67	1	1	2	1	2	-
68	1	1	2	1	2	-
69	1	1	1	1	2	-
70	1	1	1	1	2	-
71	1	1	1	-	2	-
72	1	1	1	-	2	-
73	1	1	1	-	2	-
74	1	1	2	2	1	1
75	1	1	2	2	1	1
76	1	1	2	2	1	1
77	1	1	2	2	1	1
78	1	1	1	1	2	-
79	-	-	-	-	-	-
80	-	-	-	-	-	-
81	2	2	-	2	1	2
82	2	2	-	2	1	2
83	2	2	-	2	1	2
84	2	2	-	2	2	-
85	2	2	-	2	2	-
86	2	2	-	2	2	-

87	2	1	1	1	1	1
88	2	1	1	1	1	1
89	2	1	1	1	1	1
90	1	1	2	1	2	-
91	1	1	1	1	1	2
92	1	1	1	1	2	-

Project #	General Condition of Contract	Incentive Clause	Liquidated Damage Clause	Escalation Clause
1	1	2	1	1
2	1	2	1	1
3	1	2	1	1
4	1	2	1	1
5	1	2	1	1
6	1	2	1	1
7	1	2	1	1
8	3	1	1	1
9	3	1	1	1
10	3	1	1	1
11	3	1	1	1
12	3	1	1	1
13	3	1	1	1
14	3	1	1	1
15	3	1	1	1
16	1	1	1	1
17	1	1	1	1
18	2	2	2	1
19	3	2	2	2
20	3	2	2	2
21	1	2	1	1
22	1	2	1	1
23	1	2	1	1
24	1	2	1	1
25	1	2	1	1
26	1	2	1	1
27	1	2	1	1
28	1	2	1	1
29	1	2	1	1
30	1	2	1	1
31	1	2	1	1
32	1	2	1	1
33	1	2	1	1
34	3	2	2	1
35	3	2	1	2
36	3	2	1	2
37	2	2	1	1
38	2	2	1	1
39	2	2	2	2
40	1	1	1	1
41	2	2	2	2

42	2	2	1	1
43	1	1	1	1
44	2	2	2	1
45	3	2	2	2
46	3	2	2	1
47	3	1	1	1
48	3	1	1	1
49	3	2	2	2
50	3	2	2	2
51	3	2	2	2
52	3	2	2	2
53	3	2	2	2
54	3	2	2	2
55	3	2	2	2
56	3	2	2	2
57	3	1	2	1
58	2	2	2	2
59	2	2	2	2
60	3	2	2	1
61	1	2	1	2
62	1	2	1	2
63	1	2	1	2
64	3	1	2	1
65	3	1	2	1
66	3	1	2	1
67	3	1	2	1
68	3	1	2	1
69	3	2	2	1
70	3	2	2	1
71	3	2	2	1
72	3	2	2	1
73	3	2	2	1
74	3	2	1	2
75	3	2	1	2
76	3	2	1	2
77	3	2	1	2
78	3	2	1	1
79	3			
80	3			
81	3	1	1	1
82	3	1	1	1
83	3	1	1	1
84	3	2	1	1
85	3	2	1	1
86	3	2	1	1

87	3	2	2	2
88	3	2	2	2
89	3	2	2	2
90	1	1	1	1
91	2	2	2	1
92	3	2	2	1

APPENDIX IV

DESCRIPTIVE STATISTICS

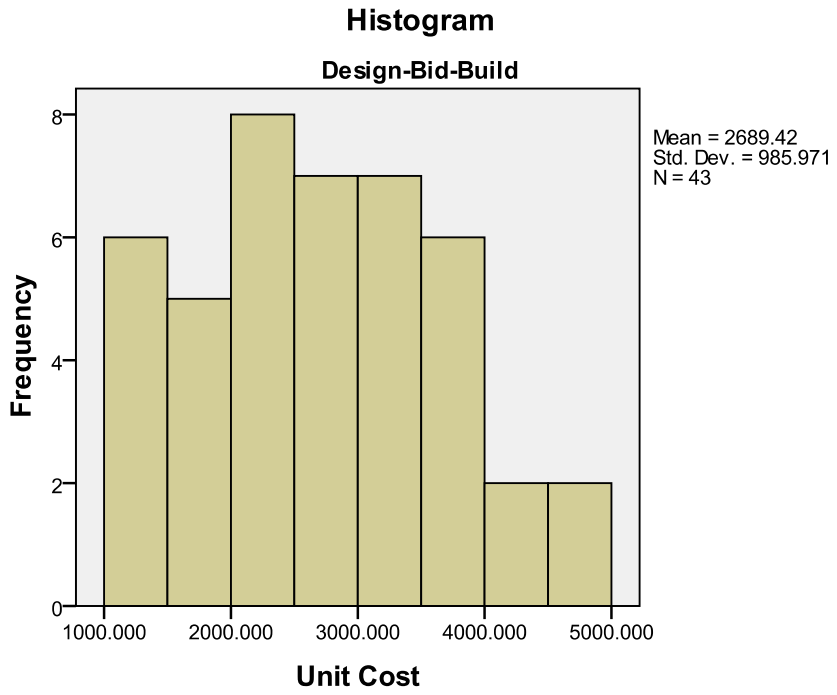
	Project Delivery Method		Statistic
Cost Growth (%)	Design-Bid-Build	Mean	17.6724
		Median	10.3865
		Variance	301.100
		Std. Deviation	17.35224
		Minimum	-4.36
		Maximum	50.00
		Range	54.36
		Interquartile Range	27.53
	Design-Build	Mean	12.2369
		Median	8.2812
		Variance	200.004
		Std. Deviation	14.14227
		Minimum	-9.07
		Maximum	43.91
		Range	52.98
		Interquartile Range	19.33

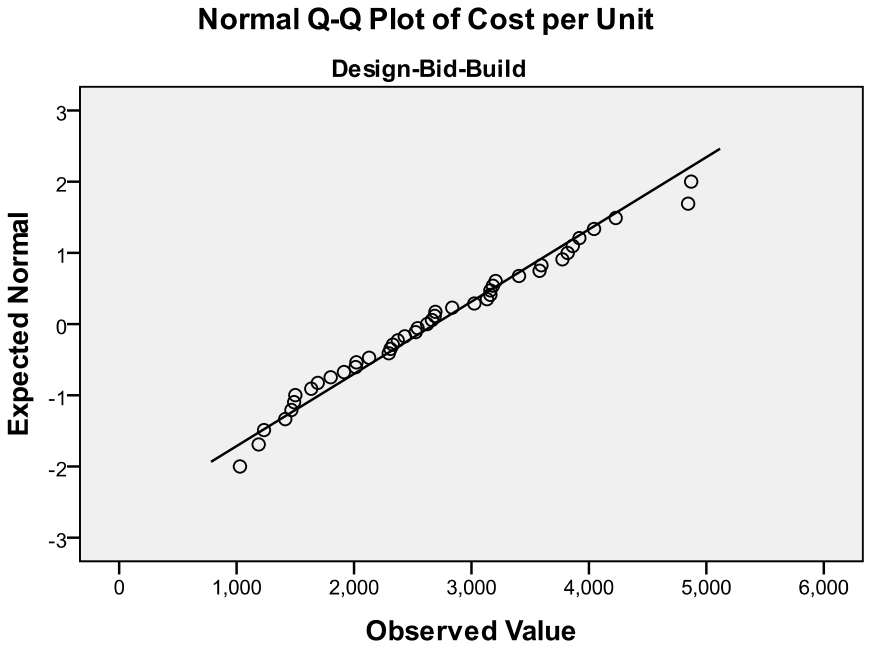
	Project Delivery Method		Statistic
Schedule Growth(%)	Design-Bid-Build	Mean	104.3866
		Median	88.8889
		Variance	7278.763
		Std. Deviation	85.31567
		Minimum	.00
		Maximum	266.67
		Range	266.67
		Interquartile Range	117.34
	Design-Build	Mean	64.1855
		Median	41.6650
		Variance	3589.669
		Std. Deviation	59.91384
		Minimum	.00
		Maximum	187.50
		Range	187.50
		Interquartile Range	84.44

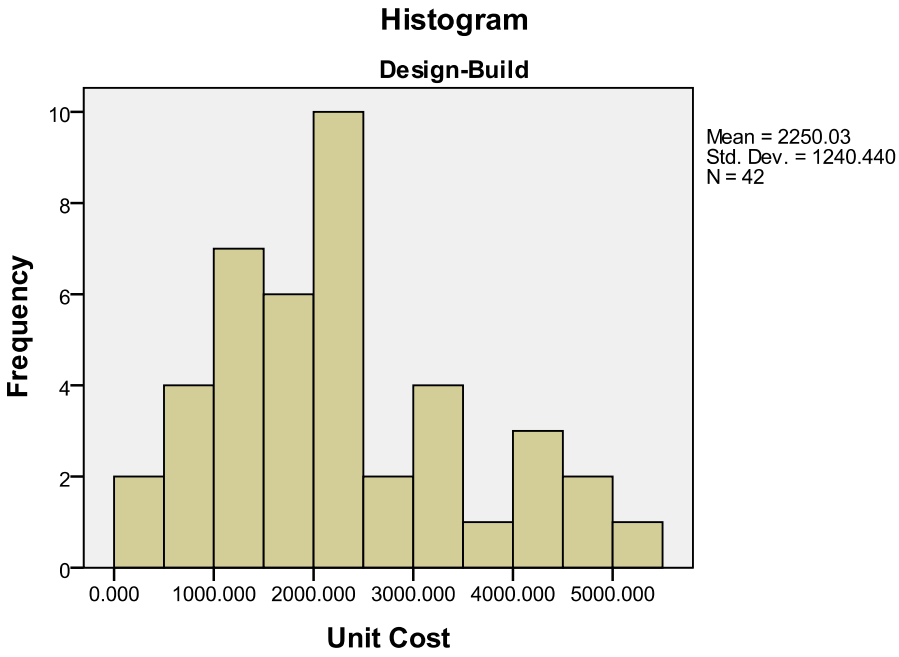
	Project Delivery Method		Statistic
Construction Speed (ft2/month)	Design-Bid-Build	Mean	3092.7373
		Median	2806.4520
		Variance	3168814.539
		Std. Deviation	1780.11644
		Minimum	363.64
		Maximum	6325.00
		Range	5961.36
		Interquartile Range	2595.32
	Design-Build	Mean	4064.4501
		Median	2400.3665
		Variance	1.579E7
		Std. Deviation	3973.60340
		Minimum	145.00
		Maximum	13333.33
		Range	13188.33
		Interquartile Range	5438.29

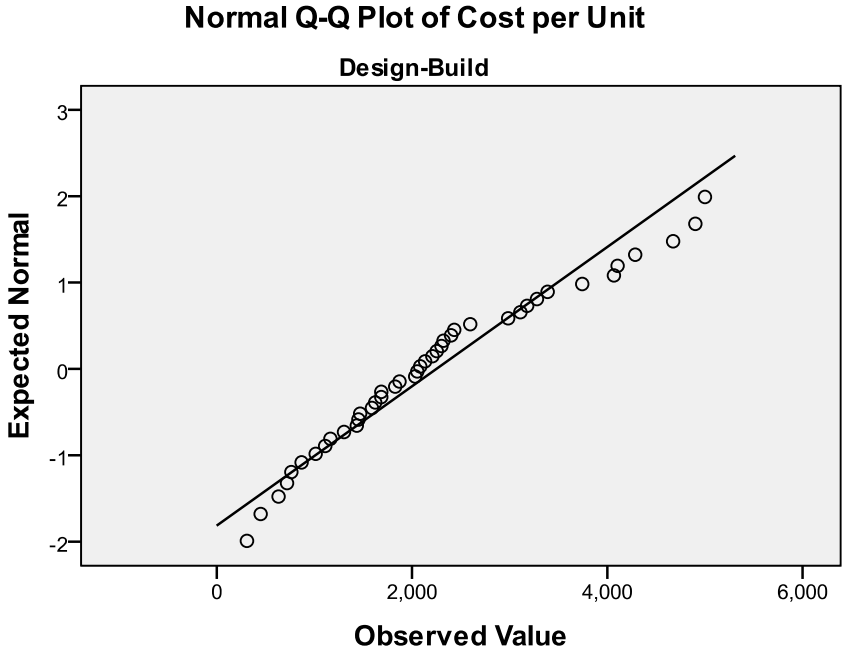
APPENDIX V

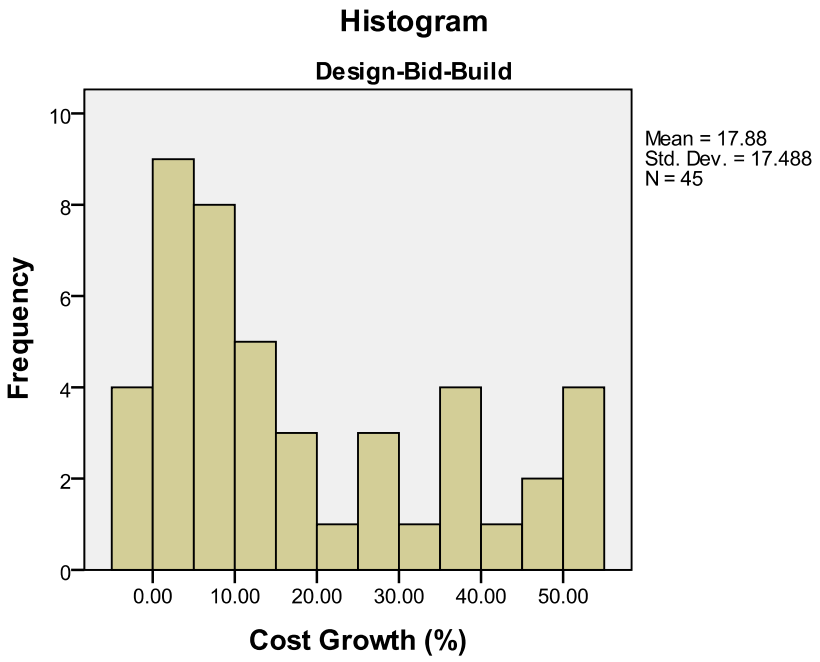
NORMALITY TEST

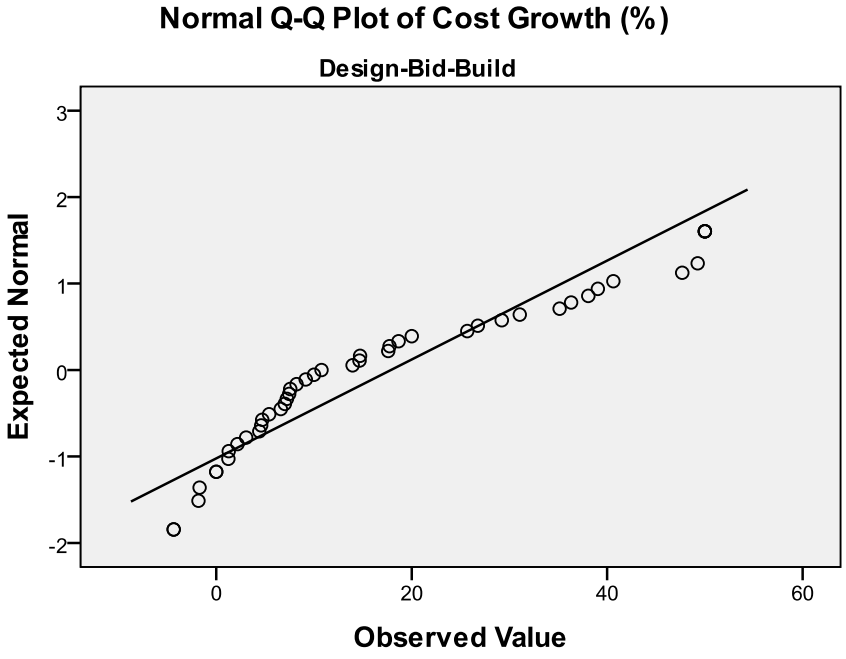


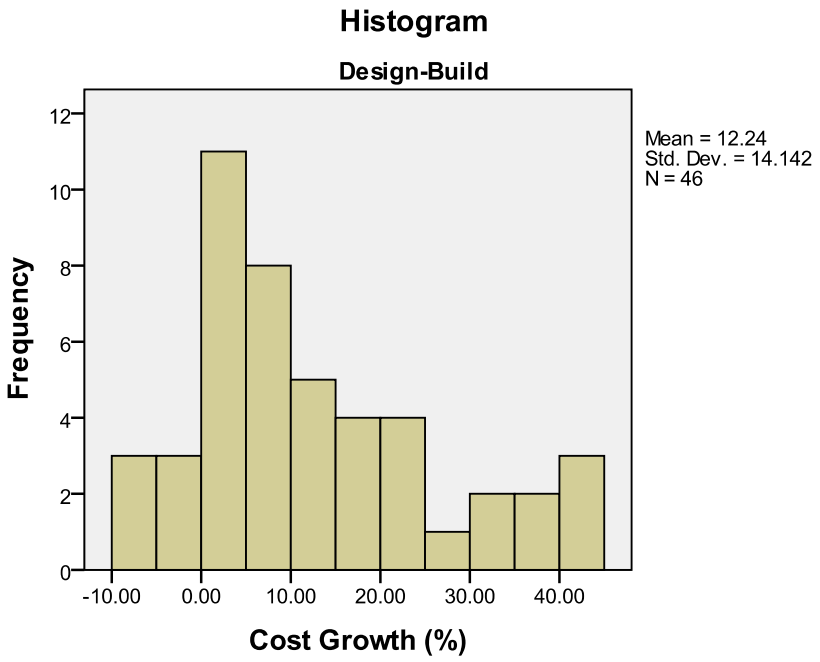


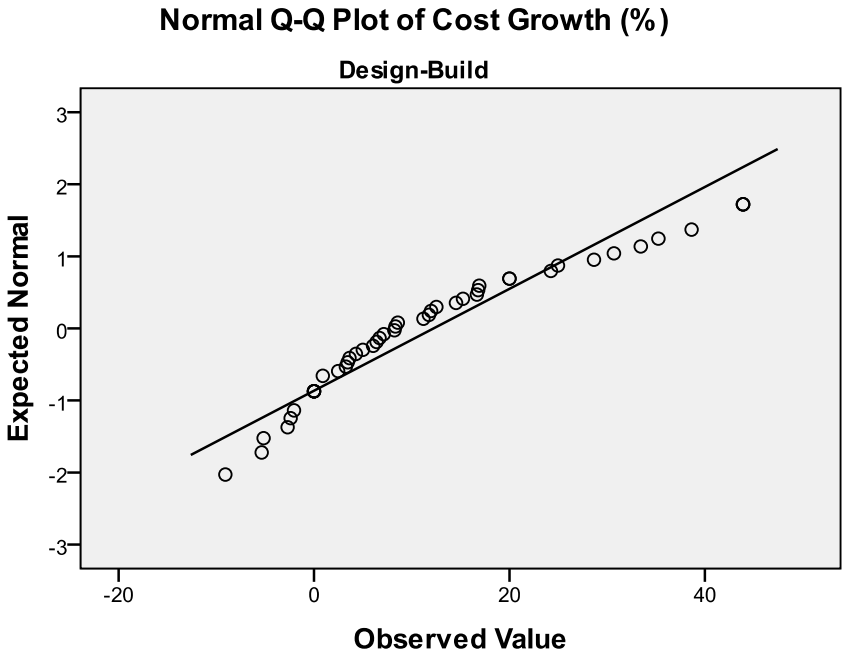

Histogram
Design-Build
Mean = 2250.03
Std. Dev. = 1240.440
N = 42
Frequency
0
2
4
6
8
10
0.000
1000.000
2000.000
3000.000
4000.000
5000.000
Unit Cost

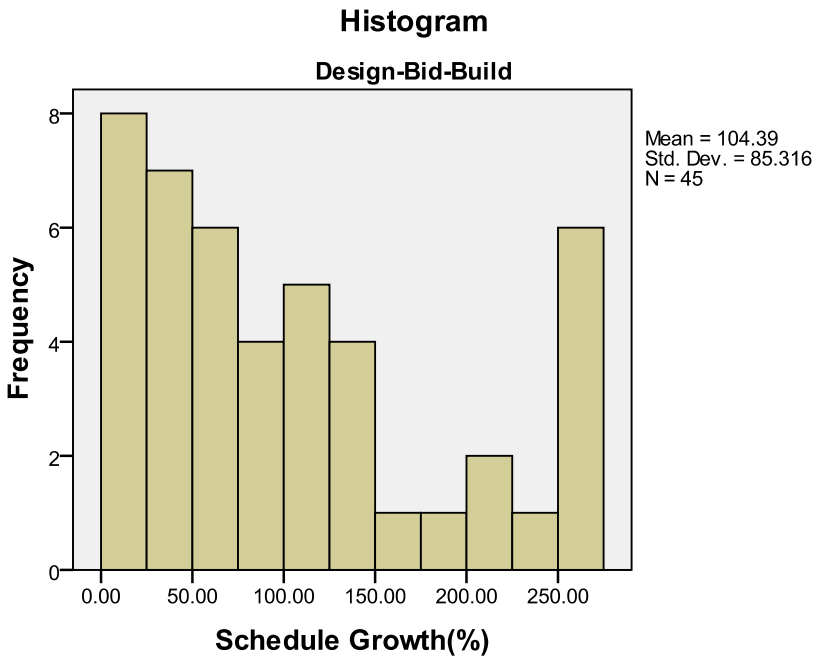

Normal Q-Q Plot of Cost per Unit
Design-Build
Expected Normal
-2
-1
0
1
2
3
0
2,000
4,000
6,000
Observed Value

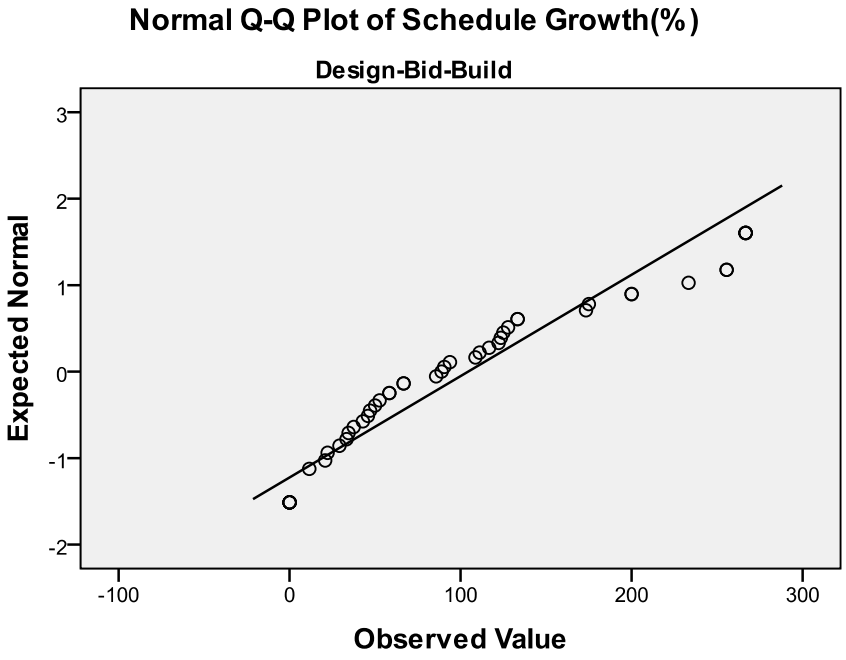

Histogram
Design-Bid-Build
Mean = 17.88
Std. Dev. = 17.488
N = 45
Frequency
Cost Growth (%)
0
2
4
6
8
10
0.00
10.00
20.00
30.00
40.00
50.00

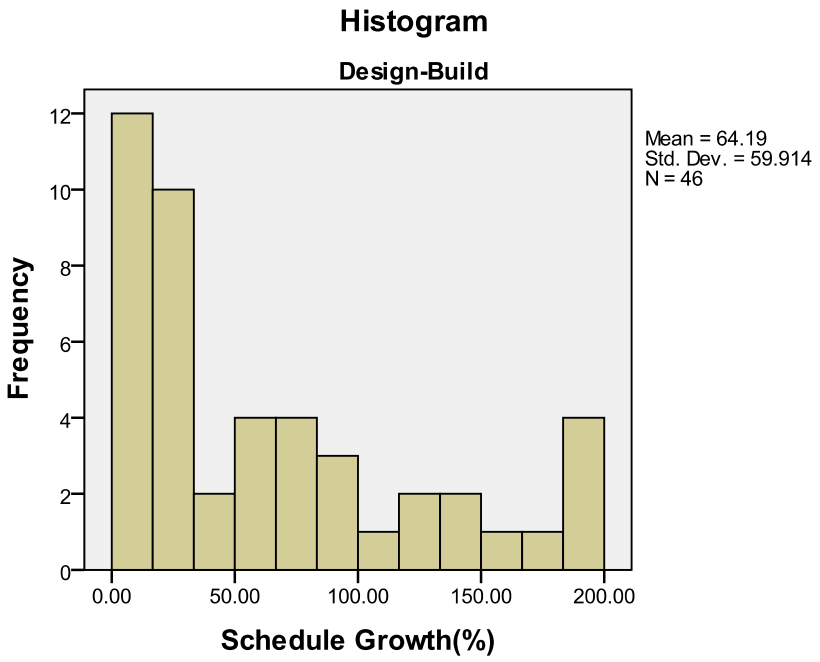

Normal Q-Q Plot of Cost Growth (%)
Design-Bid-Build
Expected Normal
Observed Value
-2
-1
0
1
2
3
0
20
40
60

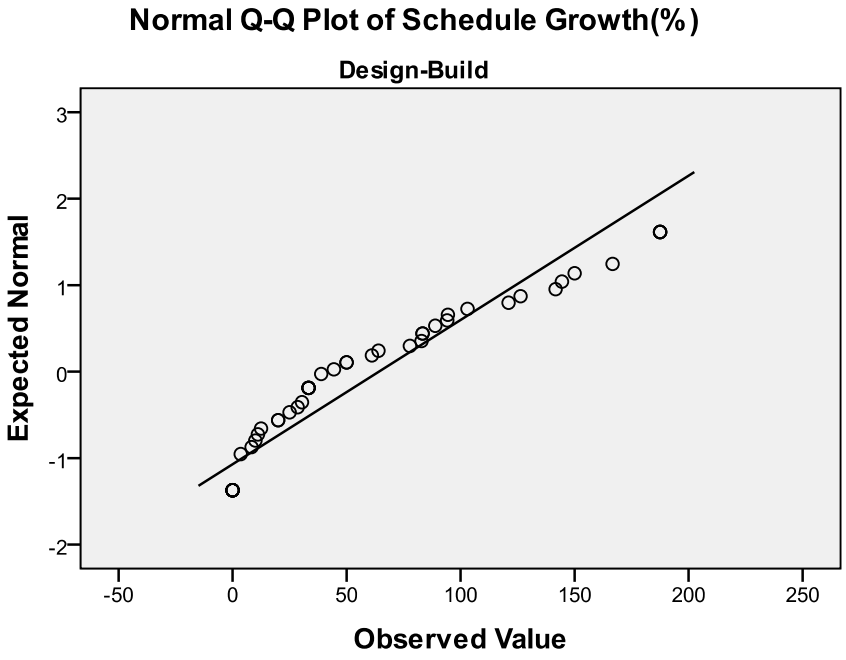

Histogram
Design-Build
Mean = 12.24
Std. Dev. = 14.142
N = 46
Frequency
Cost Growth (%)
0
2
4
6
8
10
12
-10.00
0.00
10.00
20.00
30.00
40.00

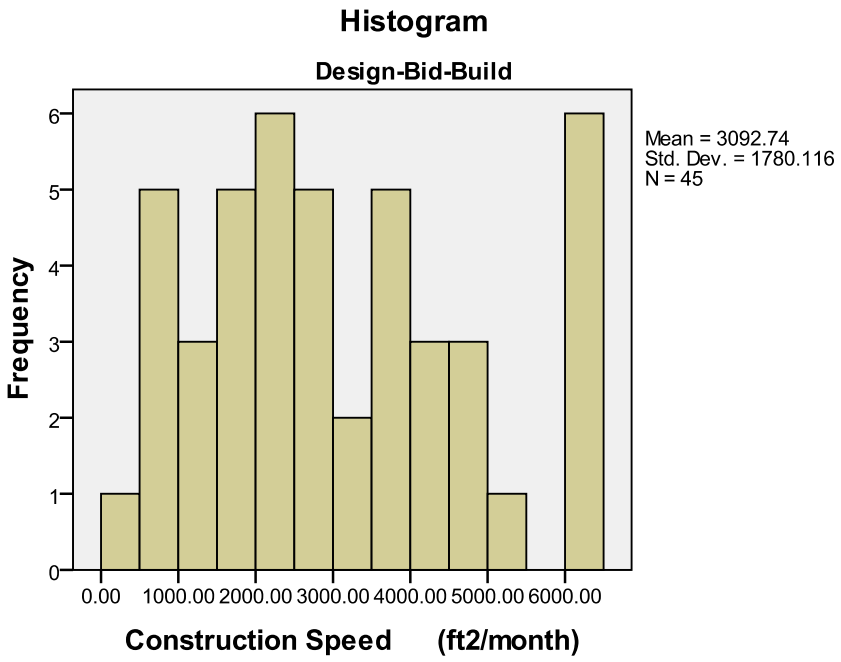

Normal Q-Q Plot of Cost Growth (%)
Design-Build
Expected Normal
Observed Value
-3
-2
-1
0
1
2
3
-20
0
20
40

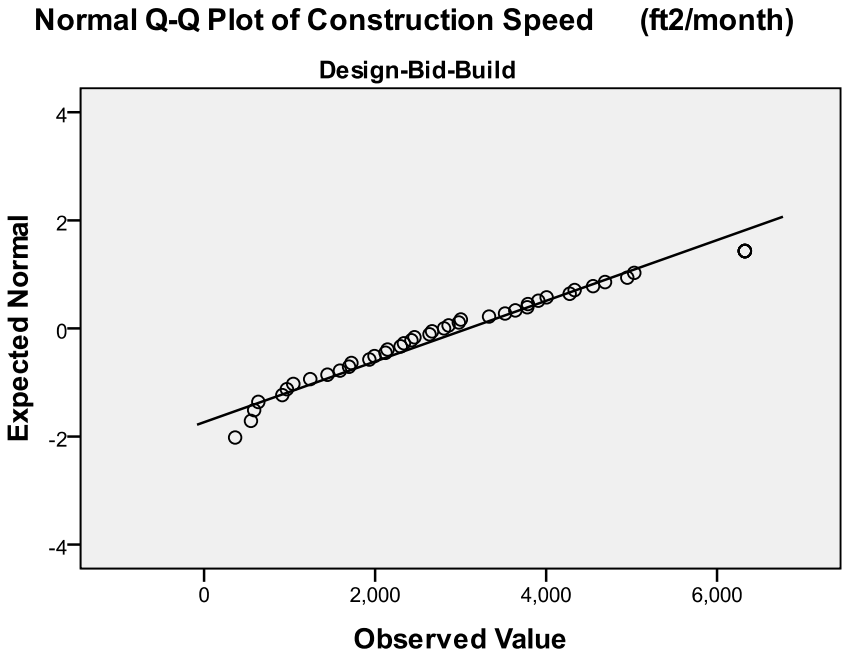

Histogram
Design-Bid-Build
Mean = 104.39
Std. Dev. = 85.316
N = 45
Frequency
0
2
4
6
8
0.00
50.00
100.00
150.00
200.00
250.00
Schedule Growth(%)

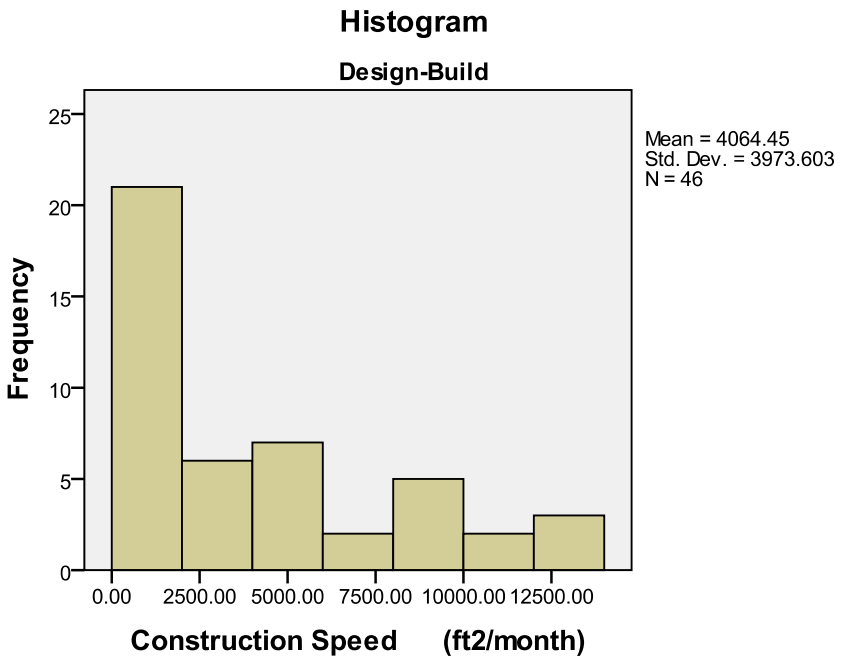

Normal Q-Q Plot of Schedule Growth(%)
Design-Bid-Build
Expected Normal
-2
-1
0
1
2
3
-100
0
100
200
300
Observed Value

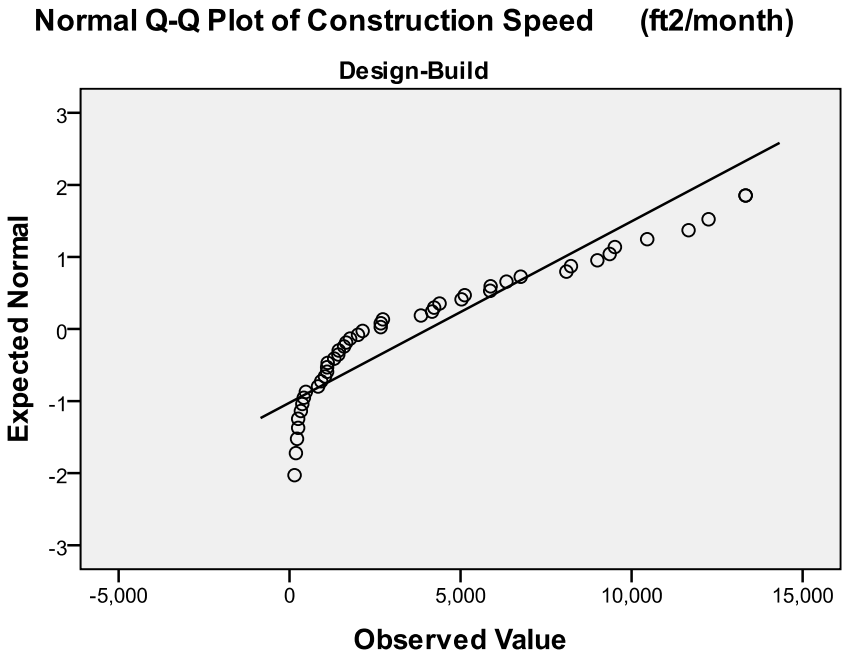

Histogram
Design-Build
Mean = 64.19
Std. Dev. = 59.914
N = 46
Frequency
Schedule Growth(%)
0
2
4
6
8
10
12
0.00
50.00
100.00
150.00
200.00


Normal Q-Q Plot of Schedule Growth(%)
Design-Build
Expected Normal
Observed Value
-2
-1
0
1
2
3
-50
0
50
100
150
200
250


Histogram
Design-Bid-Build
Mean = 3092.74
Std. Dev. = 1780.116
N = 45
Frequency
0
1
2
3
4
5
6
0.00
1000.00
2000.00
3000.00
4000.00
5000.00
6000.00
Construction Speed (ft2/month)


Normal Q-Q Plot of Construction Speed (ft2/month)
Design-Bid-Build
Expected Normal
4
2
0
-2
-4
0
2,000
4,000
6,000
Observed Value


Histogram
Design-Build
Mean = 4064.45
Std. Dev. = 3973.603
N = 46
Frequency
25
20
15
10
5
0
0.00
2500.00
5000.00
7500.00
10000.00
12500.00
Construction Speed (ft2/month)


Normal Q-Q Plot of Construction Speed (ft2/month)
Design-Build
Expected Normal
3
2
1
0
-1
-2
-3
-5,000
0
5,000
10,000
15,000
Observed Value