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AN EMPIRICAL COMPARISON OF DESIGN/BUILD AND DESIGN/BID/BUILD PROJECT DELIVERY METHODS

by

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THESIS

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AN EMPIRICAL COMPARISON OF DESIGN/BUILD AND DESIGN/BID/BUILD PROJECT DELIVERY METHODS

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Dedication

With love and appreciation to my wonderfully supportive wife, Lawre, and our amazing children AnnaGrace and Lawson Hale.

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First and foremost I thank my Lord and Savior Jesus Christ without whom I would have neither joy nor peace. I can not thank Dr. Gibson enough for his patience, encouragement and sage advice. I have truly enjoyed our relationship and it has been a true pleasure working for him. I also thank Dr. Borcherding for taking his time to review this thesis and provide valuable input based on his vast experience. Without Larry Melichamp this thesis would not have existed. His help with the data queries from FIS and explanation of all of the data was invaluable. I am also grateful to LT Eileen D'Andrea who unselfishly spent numerous hours collecting and copying the DD Form 1391's I needed. I also appreciate Steve Knight who one of the rare breed that I can count on for reliable and insightful information on everything that NAVFAC does. Finally I thank the United States Navy for giving me the opportunity for a higher education.

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Abstract

AN EMPIRICAL COMPARISON OF DESIGN/BUILD AND DESIGN/BID/BUILD PROJECT DELIVERY METHODS

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The University of Texas at Austin, 2005

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This thesis project compares the performance of a homogeneous sample of United States Navy Bachelor Enlisted Quarters built using the Military Construction process. Projects will be broken into two sub-samples of design/bid/build and design/build projects to see if one project delivery method is superior in regards to time and cost. Project duration, project duration per bed, project time growth, cost growth and cost per bed will be statistically compared. Upon completion of the analysis the hypothesis that design/build projects are superior to design/bid/build projects in regards to time and cost will be tested.

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1.0 INTRODUCTION

1.1 Purpose

As federal budgets continue to be reduced, the "Do more with less" mantra is often repeated. Funding for completing facility construction projects has been no exception. To increase efficiency the federal government has experimented with different construction project delivery methods over the last ten years. Before 1996, the Federal Acquisition Regulations (FAR) made it difficult to utilize anything except the traditional Design/Bid/Build (DBB) method. Following the private sector's lead, Congress passed a law in 1996 allowing the use of the Design/Build (DB) project delivery method (Charles, 1996). Since then various federal, state and local organizations have experimented with DB.

Naval Facilities Engineering Command (NAVFAC) has been in-step with the trend toward an increased use of DB. Unfortunately NAVFAC has had difficulty assessing the impact of using more DB contracts, because the data have been dispersed among many different databases throughout the world with no one person able to easily access all of the necessary data. Since the data were difficult to obtain and other competing tasks have prohibited data collection and analysis, no known studies that compare NAVFAC's DB and DBB projects have been completed.

This thesis will analyze empirical data from a sample of very similar NAVFAC projects. One sub-sample contains all DBB projects and the other sub-sample all DB projects. Statistical analyses will be used to determine how the project delivery method impacts various cost and time factors to determine if one project delivery method is generally better than the other.

1.2 Scope

A sample of Navy MILCON projects that constructed Bachelor Enlisted Quarters (BEQ) from FY95 to FY04 will be analyzed. The DBB sub-sample contains 39 projects and the DB sample contains 38 projects. The samples will be used to statistically compare project duration, project duration per bed, project time growth, cost growth and cost per bed.

1.3 Objectives

The objectives of this thesis are to:

1. Perform an empirical comparison of DBB and DB projects at NAVFAC. Project duration, project duration per bed, project time growth, cost growth and cost per bed will be analyzed to test the hypothesis that DB is a superior project method as compared to DBB.
2. Provide recommendations to NAVFAC based on the findings of this thesis.

1.4 Overview of Thesis

This thesis is organized into six chapters. Chapter 2 provides background information including a description of different project delivery methods and their history. The Navy, NAVFAC and its construction project process will also be described along with BEQ types. Chapter 3 discusses the research methodology including how the data was collected, how the sample was identified and the statistical analysis used. Chapter 4 provides a description of the data sample including the distributions based on the number of beds, location, building configuration, and fiscal year authorized. Chapter 5 explains the statistical results of the time and cost comparisons. Chapter 6 provides conclusions and recommendations.

2.0 BACKGROUND

This chapter will discuss different project delivery methods and their history. The Navy's facility construction command will be described along with its attitude toward DBB and DB. The process from preproject planning to construction completion for a typical major Navy construction project will be explained. The different types of barracks will also be discussed.

2.1 Project Delivery Methods

Various project delivery systems are currently in use today. Two prevalent methods are DBB and DB (Sanvido and Konchar 1998). Each of those methods are discussed below.

In a typical DBB delivery system, the owner enters into a contract with an architect/engineer firm. Based on the requirements provided by the owner, the firm *designs* construction documents called plans and specifications for the construction of the project. These documents are then used by the owner as the basis to make a separate contract with a construction company. Although many methods are used for awarding this contract, many times the owner will receive *bids* from the construction company. The construction company will then *build* the project based on the documents produced by the architect/engineer firm. Two separate contracts, with two separate entities, are utilized to complete one construction project, including two solicitations and procurement steps.

In a typical DB project delivery system, the owner provides requirements for the specified project and awards a contract to one company who will both *design* and *build* the project. Therefore there is only one contract with one entity to complete the project, and one procurement step.

2.2 History Design/Build and Design/Bid/Build

Although the DBB project delivery system is called the traditional system, having a single entity that designs and builds a facility actually predates DBB. Even before the building of the Parthenon in Athens, the group of people who were responsible for the design and construction of buildings were referred to as master builders. Some of the famous master builders are Abbe Suger who built the Gothic Royal Abbey Church of Saint Denis outside of Paris in the twelfth century, and Filippo Brunelleschi whose famous Dome of the Florence Cathederal was built in the fifteenth century (Beard et al. 2001).

The Industrial Revolution of the late eighteenth century caused the design and the construction elements of project delivery method to become separated due to the more complex requirements for buildings and the philosophies of this movement. The buildings constructed for the new manufacturing processes required design expertise and specialization for the complex systems (machinery, power distribution, chemical processes, etc.), while the construction of these buildings remained relatively the same. Another contributing factor to the separation was the ability of the designers to express their intent through plans and specifications, which enabled designers to be in remote locations from the actual construction. The builders on the other hand needed to be in the local area to complete construction.

Division of labor was an important paradigm shift emphasized during the Industrial Revolution. The difference between the intellectual process of design and the physical act of construction became a natural place for division. Furthermore, the need for capital caused constructors to rely upon nonparticipating owners (such as stockholders) to be able to purchase and operate the necessary equipment and employ the large number of laborers required for the new type of construction. The design firms did not need large amounts of capital to perform their work and chose not to consider nonparticipating member due to their professional desire to not be influenced by others. These factors brought about the separation of the design and the construction elements after the 1940's. (Beard et al, 2001).

From the Industrial Revolution to World War II, designers voluntarily coordinated with constructors, but the increased work load and legal liability of the post World War II construction boom made it more difficult for designers to continue this coordination. Owners wanted a better link between the designers and the constructors. The DB idea reemerged. Many heavy industrial facilities were design and constructed in this period using a process called E-P-C (Engineer: Procure-Construct) which is a DB process. In 1968, probably the first modern use of public funds for DB was for a school building in Indiana. Since then its use has gained popularity and the DB Institute of America predicts that half of all nonresidential construction will be DB by 2010. (Beard et al, 2001).

2.3 Design-Build Studies

Much anecdotal research that compares DBB and DB has been published, but no significant amount of published research has compared a relatively homogeneous sample of projects within one federal organization.

This thesis is a follow-up study to a Master's thesis completed 10 years ago by Roth (1995). He compared six DBB and six DB Navy childcare facilities built through the MILCON process. Using this small sample, Roth found that the use of DB significantly reduced costs associated with design and construction. The results also showed that cost growth was decreased for DB projects. However, his sample was very small from a statistical perspective and compared projects before DB began to be used significantly as an alternative project delivery method.

Ibbs et al. (2003) concluded that DB projects outperformed DBB with respect to time, but the results related to cost were not as convincing. They concluded that the skill of the project management team and the experience of the contractor had greater impacts on project performance than the project delivery method. The projects in this study were much larger than the ones studied for this thesis. Of the 67 projects studied by Ibbs, 30 projects were greater than $50 million. The largest project in this thesis's sample is about $41 million. Navy facilities are not typically as large and Congress seldom approves such large MILCON projects.

Numerous studies have shown that time can be saved by using the DB project delivery method (Songer and Molenaar 1996, Konchar and Sanvido 1998 and Molenaar et al. 1999). Songer and Molenaar (1996) used literature and anecdotal evidence vice more empirical research.

Konchar and Savido (1998) collected and analyzed data for 351 U.S. building projects comprised of six facility types. They used a multivariate model to examine unit cost, construction speed, delivery speed, cost growth and schedule growth. They concluded that DBB projects were more likely to have changes in schedule than DB. They also concluded that the DB project delivery method would show cost benefits. Bennett et al. (1996) conducted a similar study in England that also used multivariate analysis. They compared cost, schedule and quality performance. Bennett et. al.'s results were similar to Konchar and Savido.

Molenaar et al. (1999) described the evolution of the DB project delivery method and analyzed 104 public-sector design-build projects. Their results provide important analysis of cost, time and quality data for DB projects, but they do not compare a similar sample of DBB projects within the same organization.

Uhlik and Eller (1999) provide an excellent description of perceived benefits of using DB versus DBB for military medical construction projects, but have no empirical data. They suggest that a shift to DB would decrease the time to design and build new military medical facilities. They also assert that the overall cost would be reduced.

This thesis is unique in that relatively large and homogeneous samples collected from within a specific organization are compared to determine if one project delivery method outperforms the other in relation to cost and time.

2.4 Department of the Navy, Commander Navy Regions and the Naval Facilities Engineering Command

It is important to understand the purpose and the structure of the Department of the Navy, Navy Regions as well the Naval Facilities Engineering Command. The Department of the Navy is comprised of over 530,000 active duty sailors and soldiers and over 200,000 civilians. The Department of the Navy includes both the Navy and the

Marine Corps. “The mission of the Navy is to maintain, train and equip combat-ready Naval forces capable of winning wars, deterring aggression and maintaining freedom of the seas.” (CHINFO, 2005). The Marine Corps is a separate branch of the military, but falls under the auspice of the Department of the Navy. Because of this connection, the Marine Corps relies upon the Navy to provide key support elements such as medical personnel, chaplains and facilities support. The Navy consequently oversees all construction on Marine Corps bases. Therefore, the Marine Corps selection of project delivery method and construction management will be comparable to the same project built for the Navy.

The Navy has established 16 regions each with an individual commander. The commanders are responsible for the Naval bases (including the facilities) and the associated shore-based personnel within their respective region. Their mission is to support fleet elements such as ships, planes and submarines located in each region. Figure 1 shows the 10 regions within the Continental United States (CONUS) along with naming six regions outside the Continental United States, (OCONUS). These regions will be used to characterize the location of the sample projects used in this study.

Figure 1: The Navy Regions
from http://www.cni.navy.mil/regions.html

The Naval Facilities Engineering Command (NAVFAC) is the Navy's facilities experts. Employing more than 13,000 civilian and military employees, NAVFAC is responsible for the execution of the planning, design, construction and maintenance of the Navy and Marine Corps infrastructure world-wide. (Woodie, 2004). Additionally they provide expertise on environmental and crane issues as well as providing contingency engineering support to military operations around the world (NAVFAC, 2005). Annually, NAVFAC executes over $5 billion in facility-related contract actions alone. (Jacada, 2005).

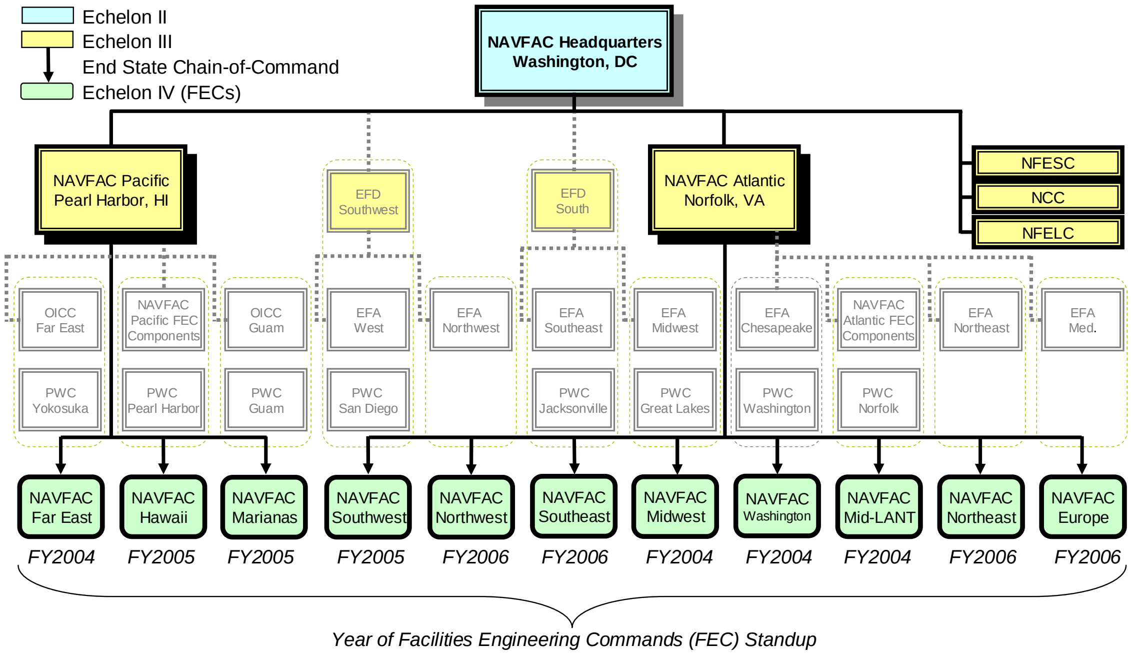

Figure 2: Current and Future NAVFAC Organization from Transformation Brief

NAVFAC is currently undergoing a transformation of its organizational structure. The old (shadowed) and future (bolded) NAVFAC organization is shown in Figure 2. The Headquarters (HQ) element is located in the Navy Yard in Washington, DC. Under the old structure the next level of organization is called an Engineering Field Division (EFD). In the old structure, four EFD's existed. Pacific Division and Atlantic Division have become NAVFAC Pacific and NAVFAC Atlantic. Southwest Division and South Division (shadowed in Figure 2) were the other two divisions in the earlier organization. Each EFD had Engineering Field Activities (EFA) that reported to them. These EFA's are shadowed on the third row of the organizational structure. For example, the dashed lines show that EFD Southwest was comprised of EFA West and EFA Northwest reporting to it. EFD/EFA's were responsible for the planning of large construction projects (such as Military Construction) and execution of these construction contracts. They had no responsibility for the facilities after construction was complete.

Currently, NAVFAC's organizational structure is shown in bold in Figure 2. The EFD/EFA concept will no longer exist. These commands are combining with the facility maintenance departments (Public Work Centers or PWC) to form a single facility organization called a Facility Engineering Command (FEC). Some of the FEC's have already been established. The estimated dates for commissioning of each FEC is shown in Figure 2.

It is important to understand that each of the EFD/EFA's were autonomous. Each one made their own project delivery method decisions and until recently seldom did NAVFAC HQ force a particular project delivery method upon the EFD/EFA. Therefore each EFD/EFA used DBB and DB to varying degrees based upon their command culture. This explains why some EFD/EFA's had relatively high number of DB or DBB projects.

Currently, NAVFAC plans to execute about 25% of the Navy MILCON projects as DBB and approximately 75% as DB.

2.5 Navy Military Construction Process

The process that a Military Construction (MILCON) project goes through from the time that the facility need is identified to the time that the project is completed can be anywhere from four to five years to as long as ten years (Uhlik and Eller, 2003). A better understanding of the process is needed as a background for the study of MILCON projects.

The Navy annually assesses and reports the condition of its facilities. The assessment considers whether the facility is in good condition and whether the facility has adequate space for users to meet their current mission. Through this report, and other means such as user request, mission critical needs, etc. the Navy identifies needed construction projects. The details of each project are input in a standard format on DD Form 1391. DD Form 1391 is the planning document used by the Department of Defense (and hence the Department of the Navy) to request funding from Congress for MILCON projects. This form supplies a scope of work, budget estimate, and justification for the project. An example of a DD Form 1391 is shown in Appendix D.

Every project valued at over $750,000 that creates a new building must be a identified as a MILCON project. Other large renovation projects can also be inputted as a MILCON project.

Every MILCON within a Navy Region is ranked and an Integrated Project List (IPL) is formed. The IPL from each region is then submitted to Commander, Navy Installations (CNI) who puts together a preliminary IPL for the Navy based on a scoring system. Representatives from every region attend a two-day conference where each region's projects are discussed. This meeting is called the CNI MILCON Review Board (formerly known as the "Shirt Sleeves Session" because proverbial shirt sleeves are rolled up and decisions are made.) The Navy's IPL is formed based on inputs from the Regional Commanders, the CNI MILCON Review Board, NAVFAC cost estimators, and from end game actions.

To better explain the MILCON project timeline a description of the step-by-step process will be given as shown in Figure 3. Assume that based on previous IPL's a project has been scheduled to be submitted to Congress for approval in Fiscal Year 2000 (FY00). The need for the new project could have been determined as early as 1995, or even earlier. Numerous factors including the condition of the existing facility to be replaced, budgetary constraints, political pressure, current focus of the Navy, and return on investment led the project to be scheduled for FY00.

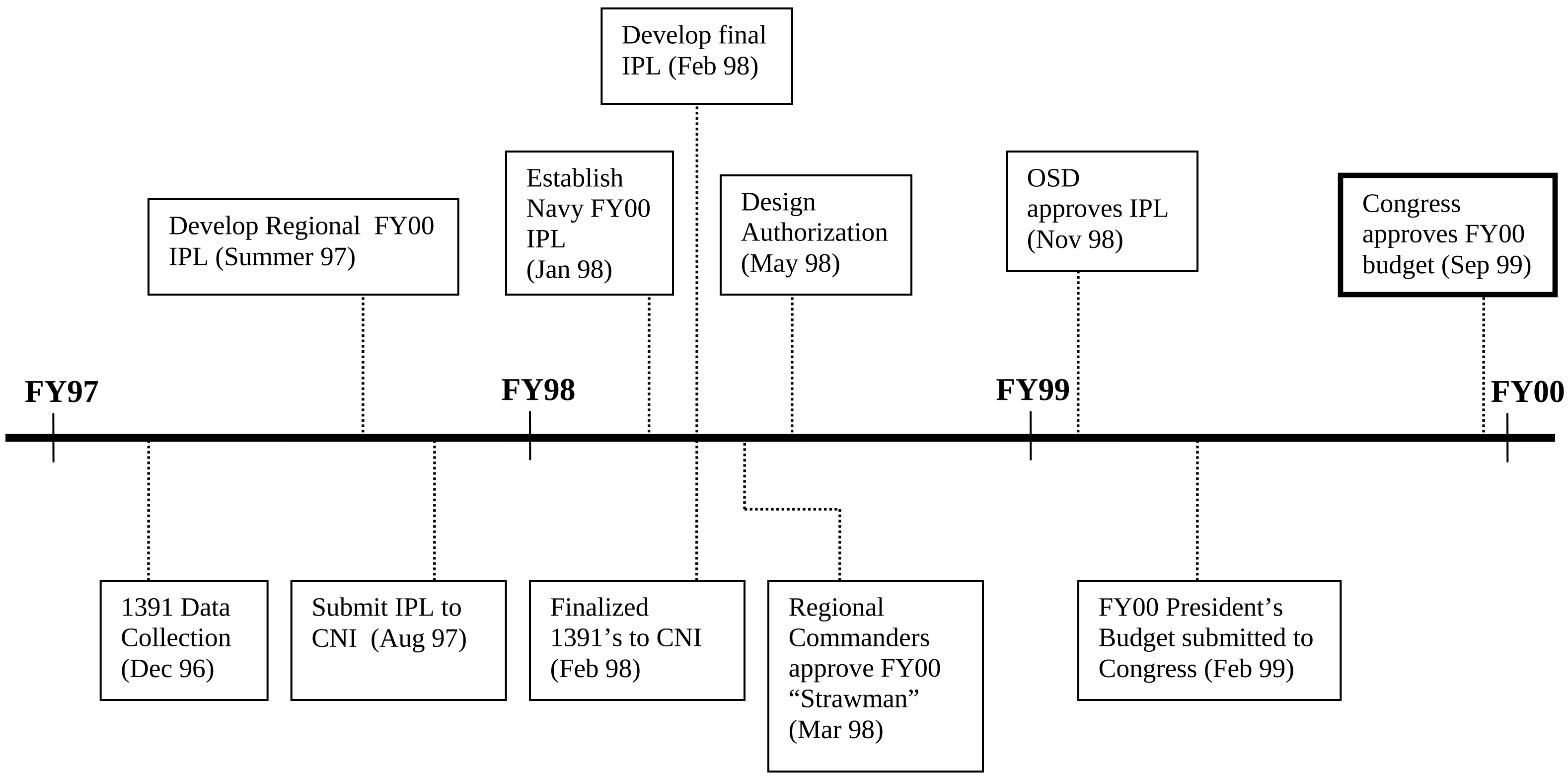

Figure 3: MILCON Process Timeline

In collaboration with the base where the new facility is to be located, data collection for the DD Form 1391 would begin as late as end of 1996. The base where the new facility is to be located would approve the DD Form 1391 in preparation for the regional ranking board. In the summer of 1997 the regional board would develop their IPL and submit it to CNI by August 1, 1997. The projects would be scored and the DD Form 1391's would be authorized by CNI. Near the end of January 1998, the project would be ranked against other Regions' projects and the Navy's IPL would be established.

After the base develops the DD Form 1391 during the summer of 1997, the EFD/EFA/FEC works to refine the cost estimates. On February 1, 1998 all finalized DD Form 1391's are submitted to CNI. Two weeks later the final IPL is developed. In March the IPL is reviewed by the Regional Commanders and their staff. They review and make changes to the IPL which becomes the Navy's "strawman." Typically in May 1998 design authorization is given for all projects that are scheduled for FY00 based upon the current strawman. Congress provides design funding but has little involvement in which projects receive design authorization.

When design authorization is received, a project delivery method has already been established. If the project is a DBB, a Request for Proposal (RFP) is developed and sent to an Architect/Engineer (A/E) firm. A contract is negotiated and the designer starts developing plans and specifications. If the project is a DB, an RFP is developed to be sent to an A/E firm so that they can develop an RFP for the DB contract. Sometimes plans and specifications for DBB and RFP's for DB projects are done by NAVFAC's in-house staff.

While the design or RFP contracts are being negotiated and awarded the project continues to move through the bureaucratic process. Around September the approved projects are forwarded to the Office of the Secretary of Defense (OSD) to ensure that the projects are timed correctly and that the projects will likely be approved by Congress. Upon approval by OSD, the projects are sent to Office of Management and Budget (OMB) to be included in the President's budget which is submitted to Congress in February 1999.

A variety of factors affect which projects are eventually submitted to Congress. The estimates can be called into question at FMB and then increased or decreased accordingly. As these estimates are increased or decreased the number of projects to be included in the President's budget submission may change. Other priorities within the Navy or the Department of Defense may require that money earmarked for MILCON projects be reduced or increased. As this amount increases projects may be added and/or removed from the strawman.

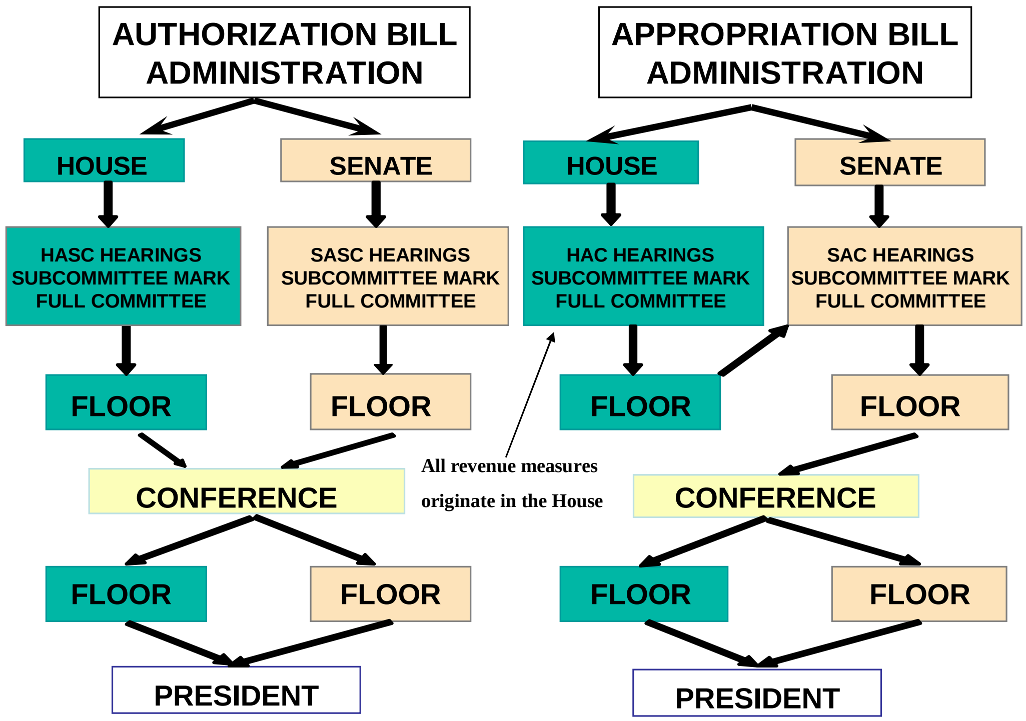

Figure 4: MILCON process through Congress from Thurber (2003).

After Congress receives the President's budget, portions of the budget are sent to the appropriate committees for review (Figure 4). The House Armed Services Committee (HASC) and the Senate Armed Services Committee (SASC) review the authorization portion of the bill. This part of the bill authorizes or approves non-financial aspects of the bill. Some projects may be "marked" which means that they are reduced in scope or cost or deleted. Other projects may be added that were not included in the Presidential submission. The bills proceed concurrently through both chambers of Congress and are eventually approved on the floor. Since different "adds" and "marks" have been made the House and Senate bills are no longer the same. The differences must be resolved in a joint conference of the HASC and SASC. After the issues have been resolved, the same bill is sent to both chambers of Congress, approved and forwarded to the President for him to sign the bill into law usually before the beginning of the fiscal year. The fiscal year starts October 1.

The Appropriation process is similar, but the bill must originate in the House Armed Services Committee (HASC). The appropriation process approves the funding aspect of the bill. After the HASC had made its “adds” and “marks”, the bill is sent to the Senate Armed Services Committee (SASC) where they do the same. The bill then takes the same path as described above from the joint committee to the enactment of the law by the President. The DD Form 1391’s that Congress approved and the President signed into law are called “as enacted” DD Form 1391’s.

From the time the DD Form 1391 was started until the projects are approved by Congress is about three years. For DBB projects, the construction must not start until after the fiscal year begins and the President has enacted the law authorizing and approving the MILCON projects. Similarly for DB projects the contractors for the project can not be solicited until after the fiscal year begins and the President has enacted the law authorizing and approving the MILCON projects.

2.6 The Evolution of the Bachelor Enlisted Quarters

The Department of the Navy has been providing housing for their military personnel since the services' infancy. During this time the accommodations have varied widely from tents to modern facilities. These facilities across all armed services are called barracks. The Navy refers to them as Bachelor Enlisted Quarters (BEQ).

In the early 1990's a committee comprised of representatives from the three armed services was appointed to study morale issues related to housing single military members. At the time a wide range of housing options existed which varied from base to base. The older facilities provided "open bay" barracks. In open bay barracks a large number of personnel lived in bunk beds in one large, open room. Bathroom facilities were also large, shared spaces. Other facilities had two to four service members sharing a room and a common bathroom on each floor. The most modern facilities were built to the latest standard called 2+2 (Figure 5). This standard provided two sleeping areas that shared a bathroom. Two people shared each sleeping area. Usually these rooms were provided to the more senior personnel (Worrell, 2002).

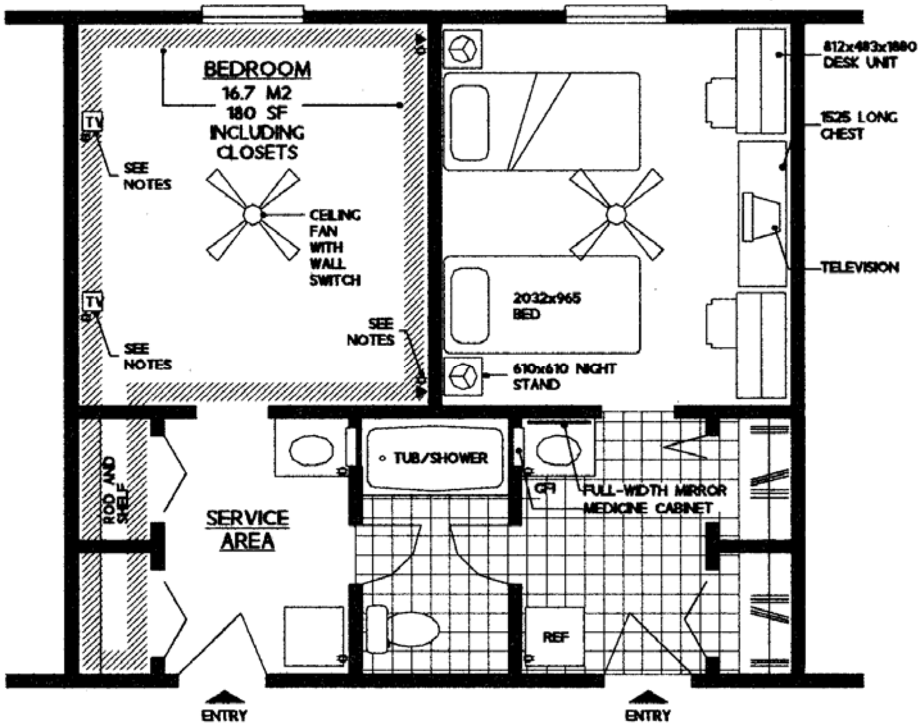

Figure 5: Typical 2+2 Room from Worrell (2002).

Based on surveys of single service members, as well as investigations of the equivalent living accommodations provided for married personnel, the committee made several recommendations for changes to the current system. They recommended increasing the size of rooms assigned to junior enlisted personnel and allowing mid-grade personnel to live in their own room and share a bath with no more than one other person (Worrell, 2002).

In 1995 the Secretary of Defense mandated a new standard commonly referred to as the 1+1 standard. Similar to the 2+2 standard, these modules (Figure 6) would provide two rooms sharing a bathroom and service area with two service members having their own room. Congress required that all services conduct an inventory of their barracks and set a goal of 2013 to obtain the 1+1 standard through renovation and new construction (Worrell, 2002).

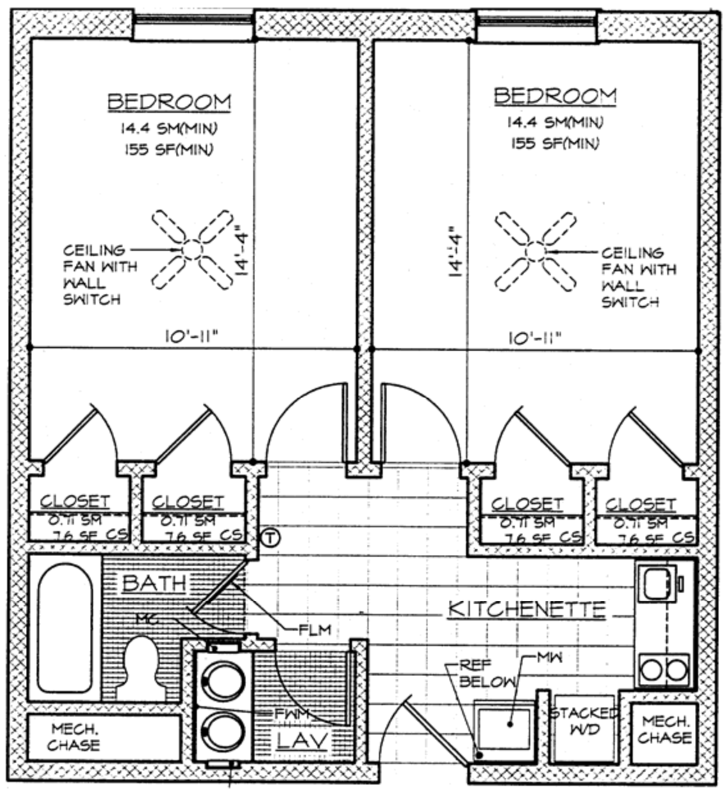

Figure 6: Typical 1+1 Room
From Worrell, 2002

The Marine Corps received a waiver of the 1+1 standard and developed a 2+0 standard unique to the Marine Corps (Figure 7). This room is similar to a typical studio hotel room. Each room holds two marines who share a bathroom (Worell, 2002). The Marine Corps made this decision to strike a balance between the privacy that the Marines desire and the unit cohesion and camaraderie that the Marine Corps desires to provide for its Marines (House Armed Services Committee, 2001).

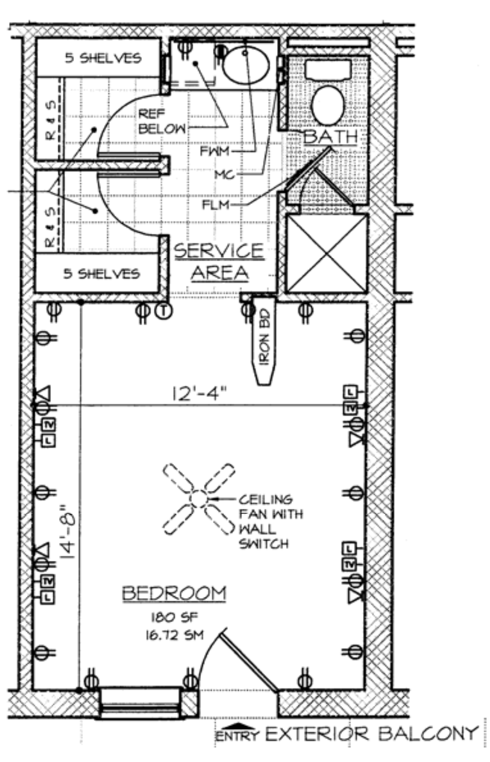

Figure 7: Typical 2+0 Room
From Worell, 2002

Although the configuration for the 1+1 and the 2+0 rooms are different, both have the same square footage for living and service areas, so comparing the cost per bed should warrant similar results as comparing cost per square foot.

The aforementioned standards are for personnel who are living in the quarters as their permanent home. Two other types of barracks are being built within the Navy for two distinct users. Recruits are housed in open bay barracks during basic training to enable a better training environment. Personnel who are temporarily assigned to a base (such as during post-basic training schools) are housed in a 2+2 room.

Due to these policy actions by Congress and the Department of Defense a large number of buildings were required to be renovated or demolished and reconstructed. Therefore BEQ's were chosen as a study sample due to the large number of projects being built while at the same time a trend toward trying new delivery methods such as design/build.

2.7 Summary

Much anecdotal research that compares DBB and DB has been published, but no significant amount of published research has compared a relatively homogeneous sample of projects within one federal (or private) organization. Numerous studies have shown that time can be saved by using the DB project delivery method. Studies have also concluded that DBB projects were more likely to have changes in schedule than DB. Some studies have concluded that the DB project delivery method would show cost benefits, but other studies did not draw the same conclusion. This thesis is unique in that a relatively large and homogeneous sample is analyzed to determine if one project delivery methods outperforms the other in relation to cost and time.

Currently NAVFAC is undergoing a shift from separate commands that perform construction and maintenance to commands that will be responsible for both construction and maintenance. The philosophy and autonomy of the organizations have not changed. Since this change began in 2003 and the projects studied were authorized from 1995 to 2003, the data will be described under the old system that used EFA/EFD's.

Pre-project planning to the start of construction of MILCON projects usually takes at least three and a half years. DB projects require Congressional approval between the completion of design and the solicitation of the construction contract. This approval can sometimes lengthen the total project time.

The BEQ has evolved in the last 10 years. The 1+1 room design for the Navy and the 2+0 room deisgn for the Marine Corps have become the standard. The sizes of these units are the same because the specifications were mandated by Congress. Therefore a comparison based on the number of beds is comparable between the two types of barracks and is similar to comparing the square footage of the barracks.

3.0 RESEARCH METHODOLOGY

This chapter will discuss the methodology used to obtain the final data sample. Figure 8 gives a flowchart outlining the methodology steps. After conducting the literature review (outlined in Section 2.3), the scope and objectives for the thesis were identified (Sections 1.2 and 1.3).

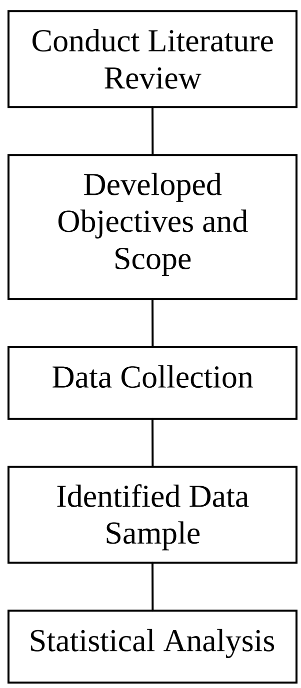

Figure 8: Research Methodology Flowchart

3.1 Identify Data Source and Collect Data

All data for this thesis was obtained through various offices of Naval Facilities Engineering Command (NAVFAC). A request was made for data pertaining to all

Military Construction (MILCON) projects to enable a comparison of DBB and DB projects. The data were originally restricted to projects approved by Congress for fiscal years 1997 to 2003. The data were exported from Financial Information System (FIS) database into a spreadsheet. FIS is a mainframe application that "provides funds management, project accounting, and contract accounting for managing construction projects" (Woodie, 2004). The data fields included description, location, project delivery method (DBB or DB), original contract amount, final contract amount, original project start date, project completion date, and category code.

The author wanted to compare similar facilities that were either DBB or DB. All facility types were analyzed to determine which facility type had the most associated projects. BEQ's had the most projects during this time period. More specific project information was requested for all BEQ MILCON projects approved from fiscal year 1995 to 2004. The data for these BEQ MILCON projects were exported from FIS into a spreadsheet.

The majority of the data collected is from this spreadsheet, however a few notable gaps in the data existed. Design start dates and total project costs were obtained from eProjects, which is a web-based project management software that enables the user to input data as well as to view data in a simple to use format that is tailored for project specific details.

The data from FIS and eProjects did not provide a detailed description of each project. Project descriptions, cost estimate information and other information were collected from a NAVFAC website or from reference copies located at NAVFAC Headquarters at the Washington DC Navy Yard. Any information that could not be gathered from these sources was collected through interviews. More information regarding data collection including detailed descriptions of FIS, eProjects and DD Form 1391 can be found in Appendices B, C and D.

3.2 Identifying Data Sample

One hundred and thirty-one BEQ projects were found in FIS that were authorized between 1995 and 2004. During the analysis of the data, many of these projects were not considered as outlined below.

Thirteen projects are open bay barracks. Open bay barracks are used for Sailors and Marines in basic training and are comprised of large open rooms with over 50 bunk beds and lockers in each room. One common bathroom/shower facility is shared by those living in that area. These barracks were not considered since the interiors of these buildings are vastly different from the other barracks. Unlike the barracks in used the sample, open bay barracks have a centralized location of the bathroom/shower facility, a significantly higher density of beds, and the heating and cooling systems requirements are significantly different since an open bay must be temperature controlled versus numerous smaller rooms.

Fourteen projects were renovations to existing buildings. The cost for renovation is significantly different since the building shell already exists. The extent of renovation could also vary widely from only a minor upgrade to a complete overhaul where only the structural members remain from the original building. Therefore these projects were not considered.

Eight projects would not finish in time for analysis in this thesis and were not considered. Two projects were built for the Air Force. Since the Air Force has different standards for their barracks, these projects were not considered.

Two projects had duplicate entries. The same project for barracks in Port Hueneme, California, and Great Lakes, Illinois were listed in two different fiscal years. The contract numbers, the project start date, original completion date and final completion date were the same for each pair of line items in the spreadsheet. The DD Form 1391's for these projects were reviewed. They indicated that the projects requested money from Congress in two separate fiscal years due to the phasing of the project, but the projects were to build the same buildings. Therefore the line items with different fiscal years were combined. The original project cost, the final project cost, and the total project cost for each line item were added together to obtain the project costs. After adding these costs, the project costs were similar to the estimates on the DD Form 1391's.

Thirteen projects were located overseas. Due to such differentiating factors as foreign currency fluctuations, differing costs for labor, and varying availability of materials, these projects were not considered.

After all of these projects were removed 77 projects remained. These projects were divided into two sub-samples based upon the project delivery method chosen. The DBB sub-sample contained 39 projects. The DB sub-sample contained 38 projects.

The Engineering News-Record Construction Cost Index was used to calculate the rate of inflation. The latest project was authorized by Congress in 2004, therefore the total barracks project cost was adjusted to 2004 costs. The total adjusted barracks project cost was obtained by multiplying the total barracks project cost by the 2004 annual average then dividing by the respective year's annual average (Table 1). This value was divided by the total number of beds to obtain the cost per bed.

Table 1: Construction Cost Index from Grogan (2005).

Year	Average
1995	5471
1996	5620
1997	5826
1998	5920
1999	6059
2000	6221
2001	6334
2002	6538
2003	6695
2004	7115

3.3 Statistical Analysis

Statistical analysis was used to determine if one project delivery method was better than the other. A two-tail, single factor Analysis of Variance (ANOVA) was used for most comparisons to determine if differences were statistically significant. The confidence level selected for the analysis was 95%. The ANOVA assumed a null hypothesis that the means of the DB and DBB sub-samples were equal ($\mu_{DB} = \mu_{DBB}$). For the null hypothesis to be false, the p-value must be less than or equal to 0.05. Given that the null hypothesis is true, the p-value represents the probability of observing a random sample that is as at least as large as the observed sample. If the p-value is below 0.05, the difference in the means is considered to be statistically significant. If the p-value is greater than 0.05, but less than or equal to 0.10 the difference in the means is considered to moderately significant. If the p-value is greater than 0.10 then the difference in the means is considered to be weakly or not significant.

4.0 DATA DESCRIPTION

This chapter will present the data set used to compare project time, days per bed, time growth, cost per bed and cost growth. The attributes of the DBB and DB sub-samples will then be compared to each other.

4.1 Data set

As discussed in Section 3.1, 77 MILCON BEQ projects were selected to compare project duration, project duration per bed, project time growth, cost growth and cost per bed. The number of projects in each sample, coincidentally, turned out to be quite evenly distributed with 38 DBB projects and 37 DB projects. The minimum and maximum project duration was 375 days and 3,160 days respectively.

Table 2: Statistics for Number of Beds

	Design/Build	Design/Bid/Build	Total
Sample Size	38	39	77
Mean (beds)	329.47	275.44	302.10
Median (beds)	341	278	316
Std. Dev (beds)	158.10	154.05	157.40

The barracks projects ranged from 40 beds to 820 beds (Figure 9). The Adjusted Project Cost varied between $4,697,462 and $41,527,036. The projects were built in 18 different states and the District of Columbia.

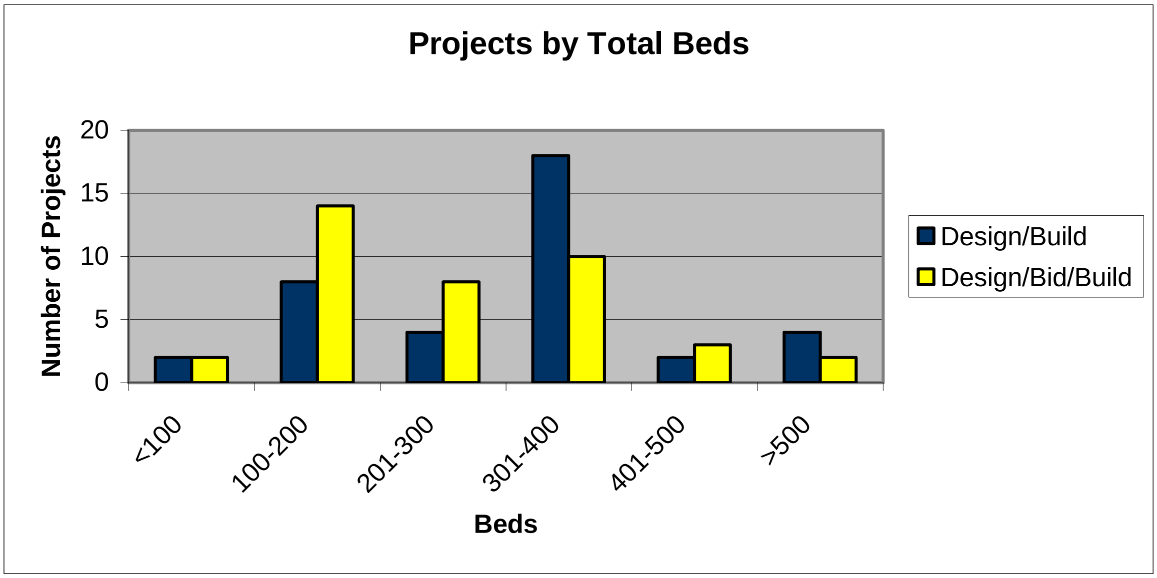

Figure 9: Histogram for Projects by Total Beds

As discussed in Section 2.4, Navy Regions divide up the United States into 10 Regions. An analysis of the projects distribution among the regions will give an idea of the geographic dispersion of the projects. As
Figure 10 shows, the projects were not evenly distributed among the Navy Regions. Navy Region Southwest had 28 projects which is about 1/3 of the total projects. Three other regions had eight or more projects: Navy Regions Hawaii (9), Mid-Atlantic (9) and Southeast (12). All of these regions except Navy Region Mid-Atlantic have large Marine Corps bases.
Figure 10 shows that 27 projects (35%) studied occurred on four Marine Corps bases.

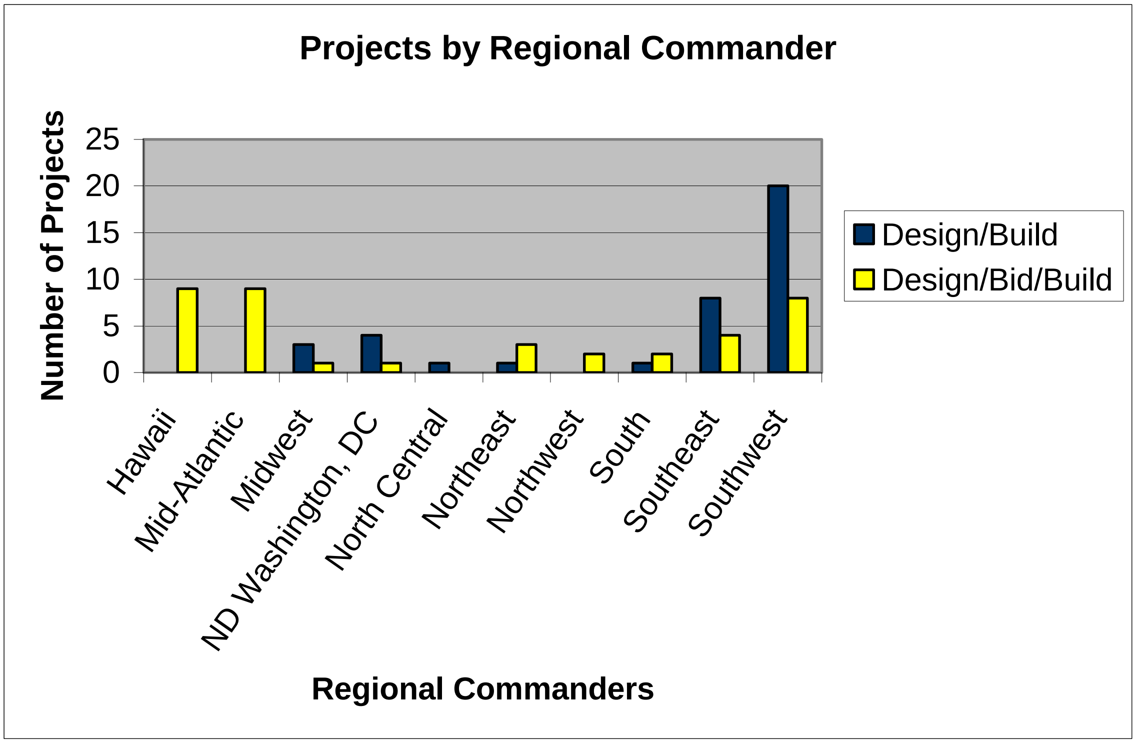

Figure 10: Distribution of Projects by Regional Commander

The BEQ's were built on 40 military bases throughout the United States. Table 3 shows the 16 bases that had more than one project. Camp Pendleton and and Twenty-nine Palms had the most DB projects with eight and six respectively. Kaneohe Bay had the most DBB projects with six.

Table 3: Bases with More than One Project

	Design/Build	Design/Bid/Build
BEAUFORT SC MCAS	1	1
BRUNSWICK ME NAS	1	1
CAMP LEJEUNE NC MCB	3	1
CAMP PENDLETON CA MCB	8	3
EVERETT WA NAVSTA	0	2
GREAT LAKES IL NH	3	0
GULFPORT MS NCBC	2	0
INGLESIDE TX NS	1	1
KANEOHE BAY HI MCB	0	6
LEMOORE CA NAS	0	2
NEW RIVER NC MCAS	0	2
PEARL HARBOR HI NS	0	2
PORTSMOUTH VA NORFOLK NSY	0	2
SAN DIEGO CA NAS NORTH IS	2	0
TWENTYNINE PALMS CA	6	0
YUMA AZ MCAS	2	0

The influence of the Marine Corps barracks can be seen in the distribution of the types of configuration. As discussed in section 2.4, the Marine Corps chose to have a 2+0 room design.

Figure 11 shows that of the 77 projects, 40 were 2+0 configurations. This means that these 40 projects were all on Marine Corps bases. A study in 1996 showed that Marine Corps barracks had been neglected for a long time and a new push existed to improve these circumstances.

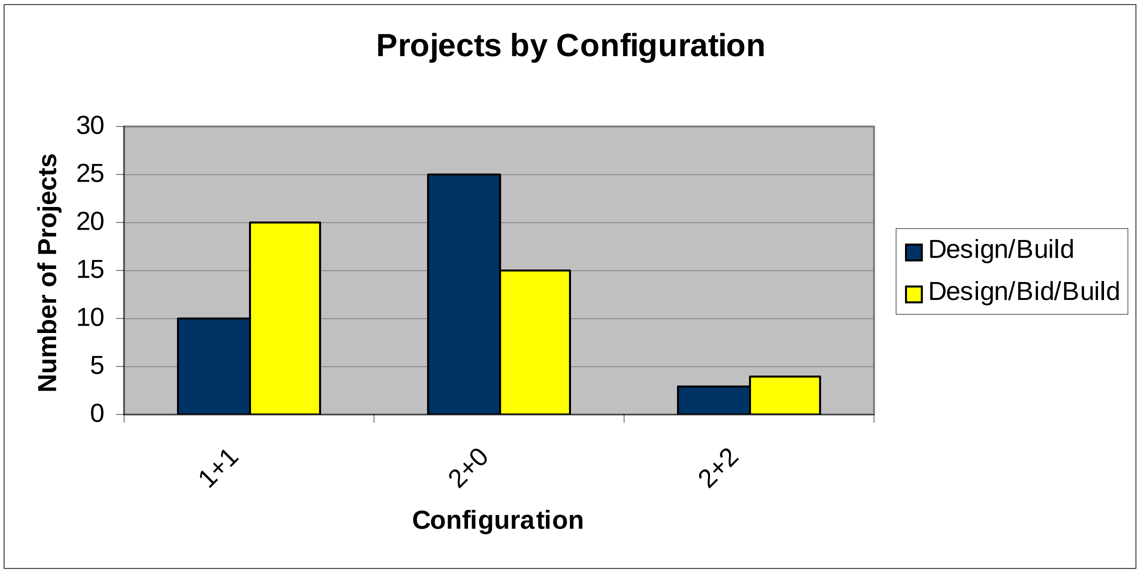

Figure 11: Projects by Room Configuration

Each EFD/EFA has a separate organizational structure. Each organization has predispositions and opinions of project delivery method. These philosophical differences can be seen in the number of DB projects that EFD Southwest included in the sample. This division completed 20 projects which is more than half of the DB projects in the sample. The second highest EFD/EFA using DB was EFD South who completed 10 DB projects. These data indicates that EFD Southwest was more progressive in choosing their project delivery method. The projects were also examined by Engineering Field Divisions (EFD) and Activities (EFA) as shown in

Figure 12. This analysis is unique to the Navy Region comparison because the EFD/EFA's do not align with the Navy Regions. This data is more important than just a comparison of regional distribution.

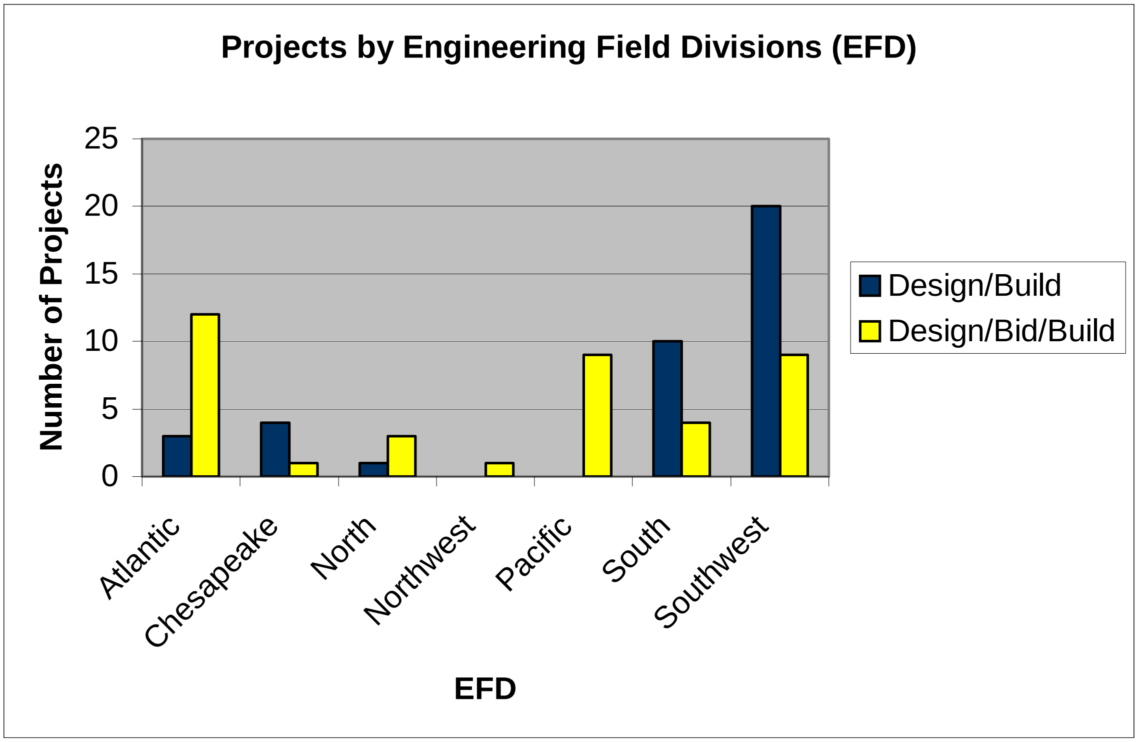

Figure 12: Projects by Engineering Field Division

The histogram showing projects by Navy Regions (
Figure 10) illustrates an uneven spread of projects when comparing the sub-samples. A disproportionate number of DB projects were executed in Navy Region Southwest and some regions that executed several DBB projects did not construct any DB projects. Figure 12 shows similar results when comparing EFD/EFA distribution of projects. The table showing bases with more than one project (Table 3) explains that a few bases are disproportionately represented in the sample. Therefore we can conclude that a locational bias may exist in the sample analysis.

Eventually EFD Southwest's success with DB led to a general trend of more DB projects being executed by NAVFAC. Although no official policy exists the design funds are requested based upon the assumption that about 25% of the MILCON projects will be DBB and 75% will be DB. Figure 13 compares the number of DBB and DB projects by Fiscal Year. A trend appears to be seen toward an increase in the use of DB as the project delivery method of choice, but it is difficult to analyze since the number of projects varies greatly from year to year. Figure 14 more clearly shows an increased of use of DB as the project delivery method of choice as time passed.

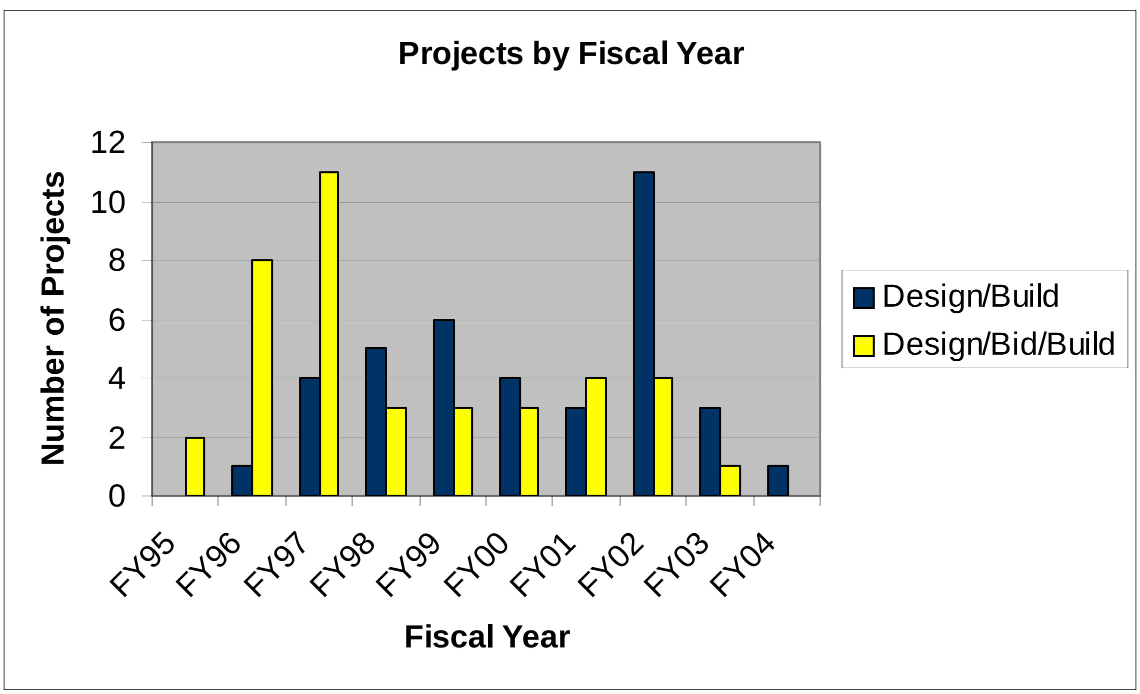

Figure 13: Projects by Fiscal Year

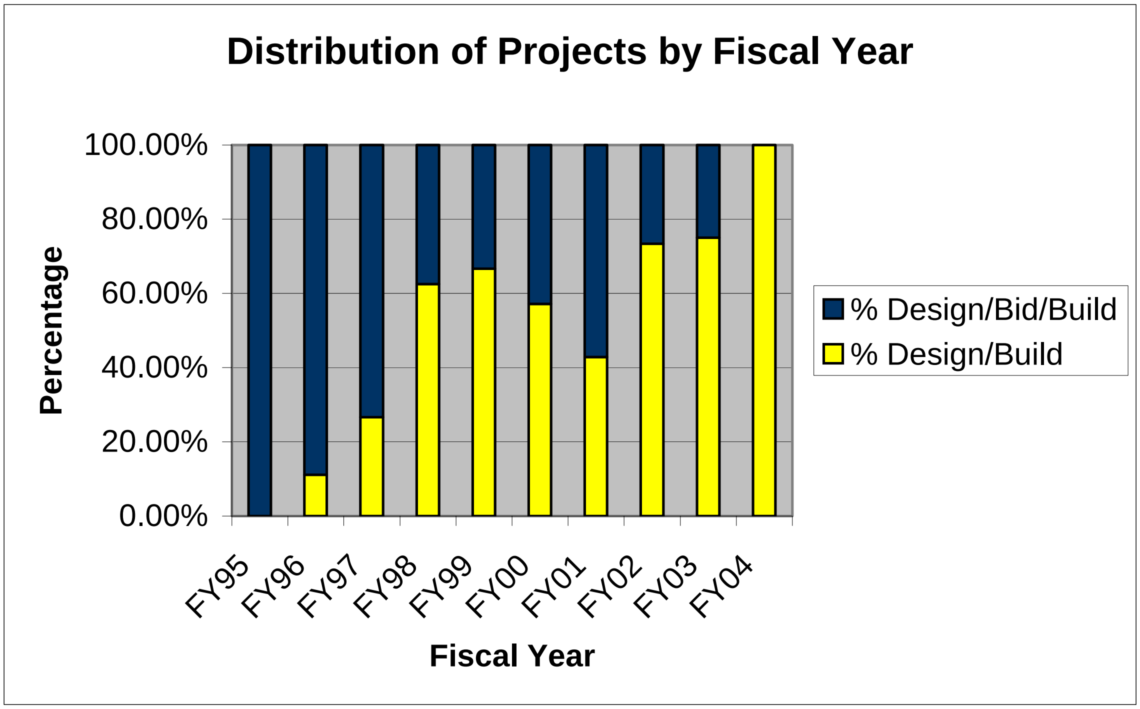

Figure 14: Distribution of Project by Fiscal Year

4.2 Summary

The data presented shows that the sub-samples are similar in many regards. The distributions for the sub-samples of number of total beds both appear to be normal and have similar ranges. The total project costs have similar ranges. The only significant difference may be in the location of the projects. When the sub-sample were compared based on the Navy Regions or the EFD/EFA's the distributions were not as similar as other comparisons.

5.0 DATA ANALYSIS

This Chapter will compare the two sub-samples as they relate to time and cost. Total project duration will consider time in three manners. The first comparison (Total Project Duration) will be based upon time from the first contract action (design contract award for DBB and project contract award for DB) to project completion. The next comparison of time (Fiscal Year Duration) will be from the fiscal year the project was authorized to project completion. The final duration (Project/Construction Start Duration) will be from the first contract action after the fiscal year (construction contract award for DBB and project contract award for DB) to project completion. Time growth will be analyzed based upon the number of days the contract increased. The final time element that will be compared is the number of days per bed to complete the project. Cost per bed and total project cost growth for the two sub-samples will also be analyzed.

5.1 Project Duration

The length of time to complete a project is an important element of contract delivery method performance. The *Total Project Duration* will be calculated as the difference between the date of the first contract action and the project completion.

5.1.1 Total Project Duration

The first contract action for DBB is the award of the design contract. Therefore the Total Project Duration for DBB projects included the length of the design contract, the length of solicitation and award of the construction contract, and length of the construction contract. The first contract action for the DB projects was the project contract award date. Therefore the Total Project Duration included the length of the contract for the design and construction of the project. Figure 15 and Figure 16 show timelines of actual DBB and DB projects respectively. These timelines are provided as examples of a typical timeline for a project and to graphically show the various project durations that will be examined. Figure 17 and Figure 18 are histograms showing the duration distribution of projects.

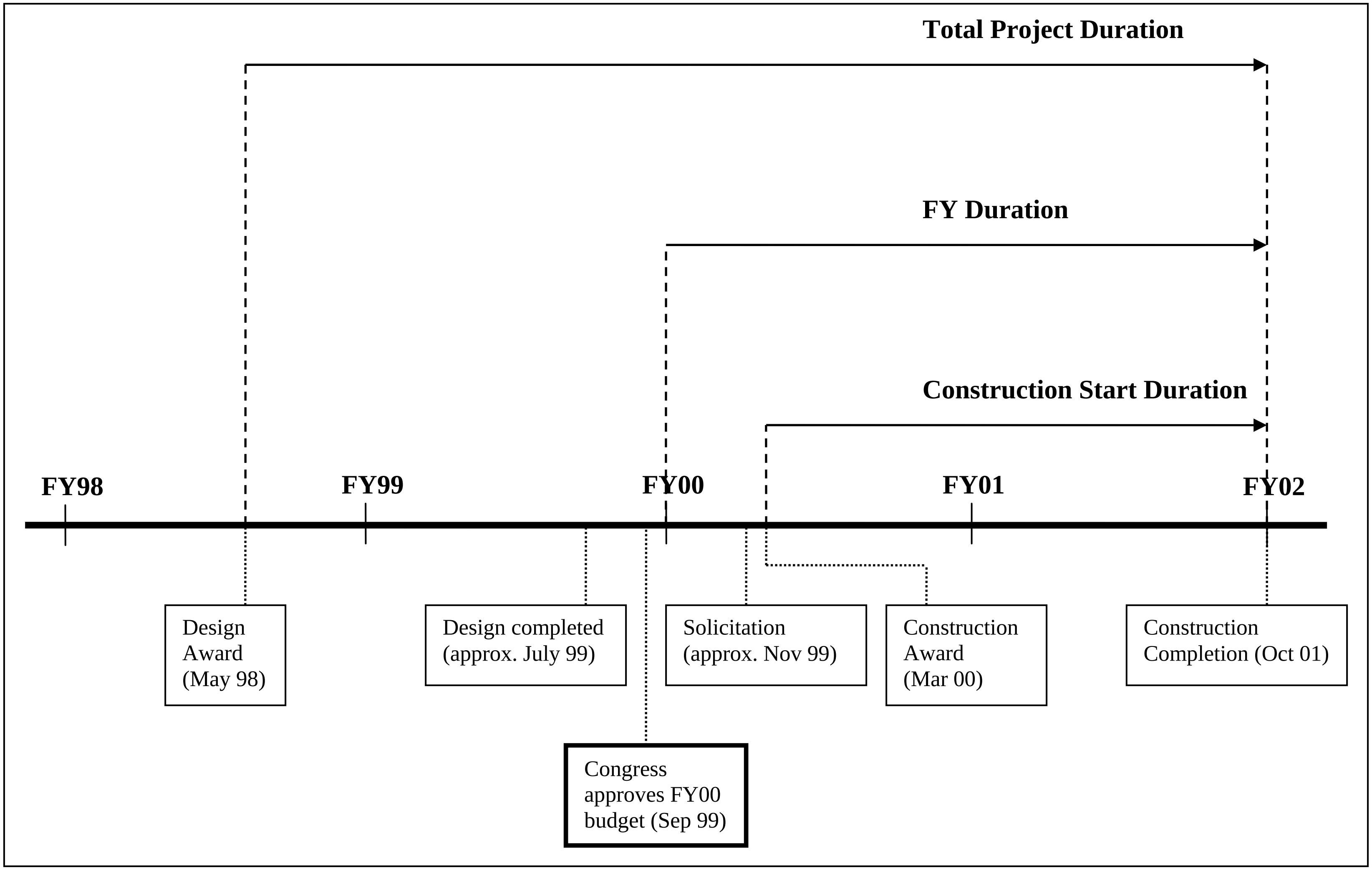

Figure 15: Timeline for DBB-29

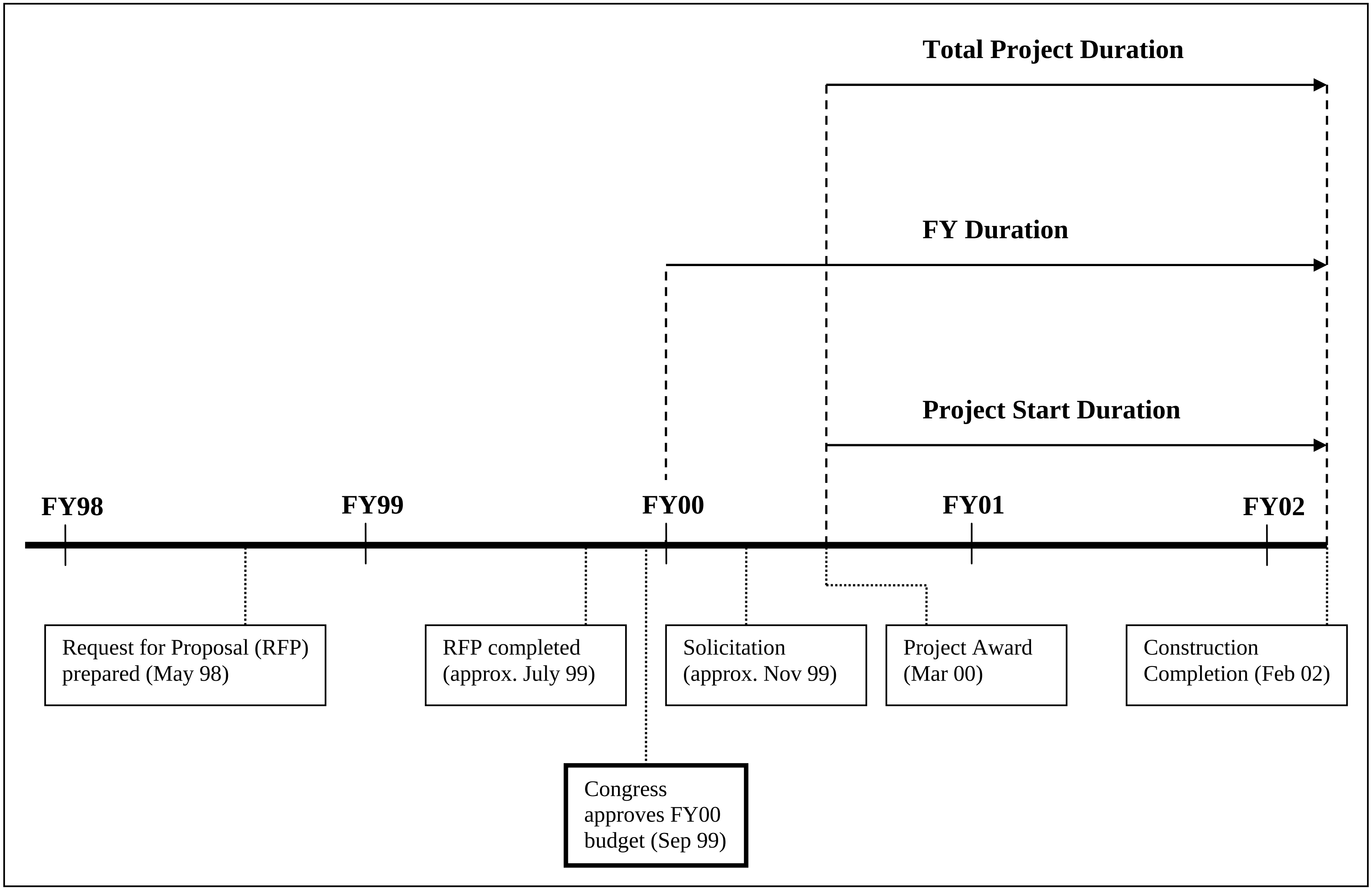

Figure 16: Timeline for DB-17

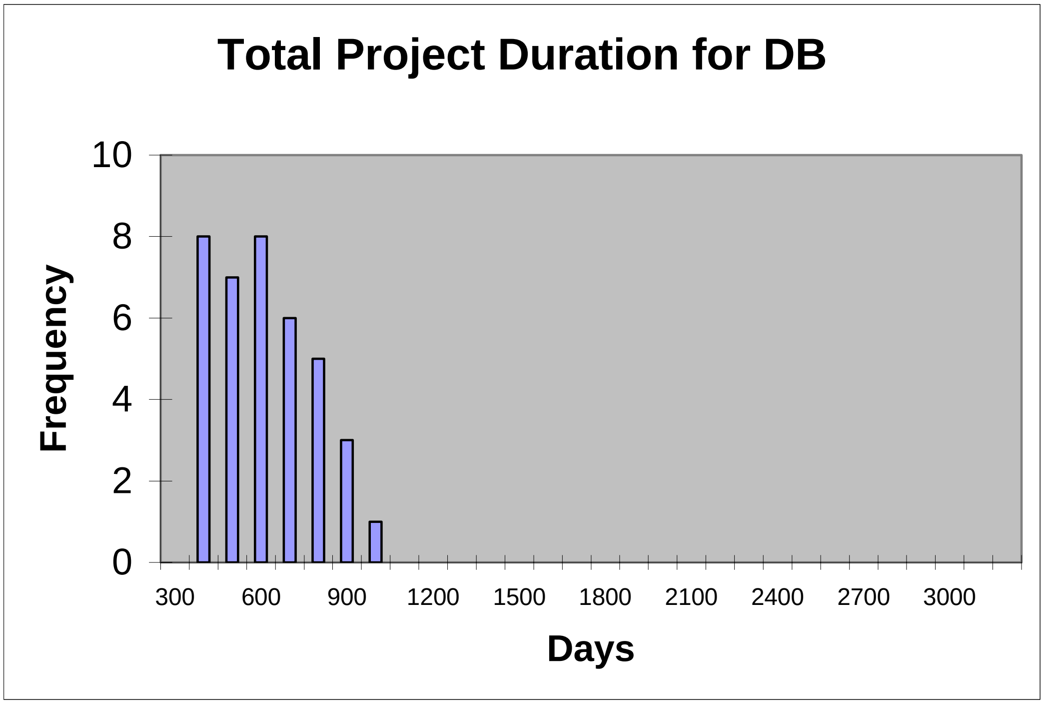

Figure 17: Total Project Duration for DB projects (N=38)

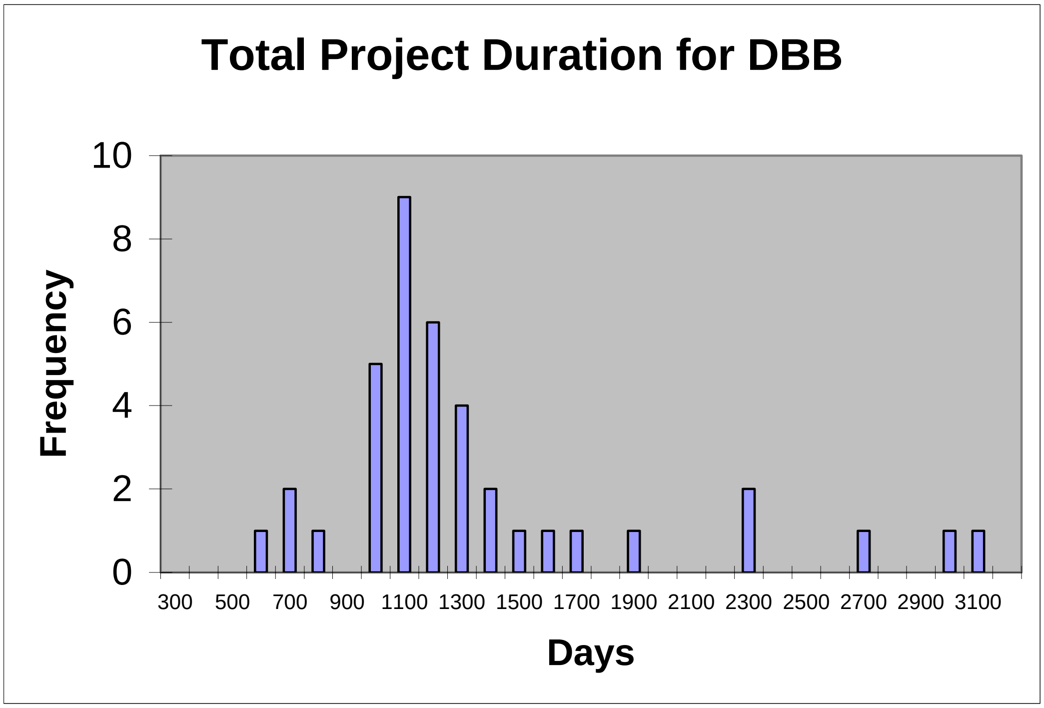

Figure 18: Total Project Duration for DBB projects (N=39)

Although the average number of beds per project is relatively similar (329 for DB and 275 for DBB), the figures show two markedly different distributions. Figure 17 shows the DB projects clustered between 500 and 1200 days. Conversely, the DBB projects shown in Figure 18 shows a much wider distribution with the peak of the distribution shifted to the right significantly. Although no DB projects exceeded 1200 days, the majority of DBB projects did.

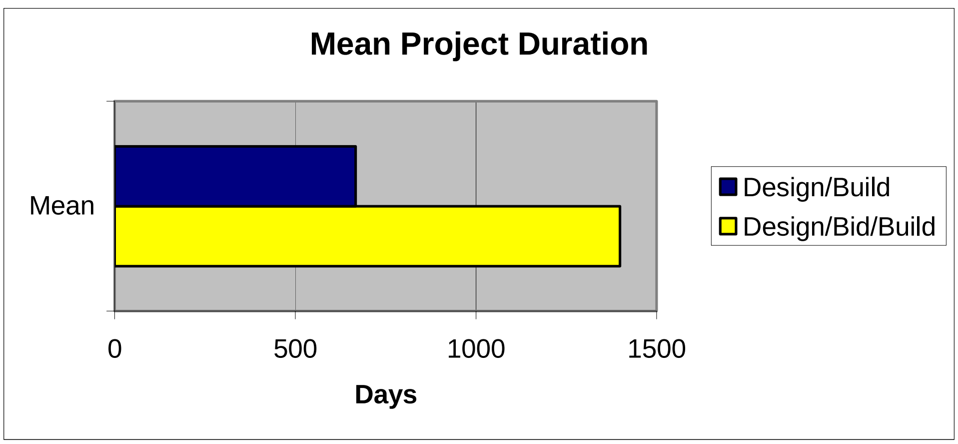

Figure 19: Mean Total Project Duration

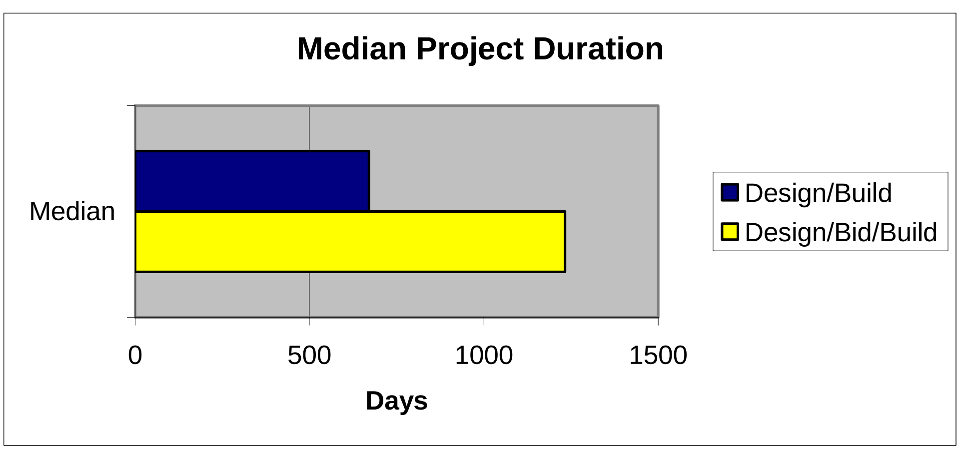

Figure 20: Median Total Project Duration

The statistics concur with the observations related to the histogram. Figure 19 and Table 4 show that the mean DB duration is less than half of the mean DBB duration. Also as shown with the histogram observations in Figure 20 and Table 4, the median of the DB data is near the average duration. The median for the DBB data is lower than the mean due to the high number of projects that are significantly higher than the mean this skewing the sample. Also, DB projects seem to be much more consistent as shown by the lower standard deviation.

Table 4: Statistics for Total Project Duration

	Design/Build	Design/Bid/Build
Number of Projects	38	39
Mean (days)	667	1398
Median (days)	671	1233
Standard Deviation (days)	173	584

An analysis of variance (ANOVA) was conducted to determine if the means of the two samples were the same (Albright et al., 2003). The null hypothesis was that $\mu_{DB} = \mu_{DBB}$ where μ_{DB} = the mean duration for the DB sample and μ_{DBB} = the mean duration for the DBB sample.

Table 5 shows the results.

Table 5: Single Factor ANOVA for Total Project Duration

Groups	*Count*	*Sum*	*Average*	*Variance*
Design/Build	38	25342	666.8947	29842.26
Design/Bid/Build	39	54641	1401.051	338854.3

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	10373727	1	10373727	55.65055	1.26E-10	3.968471
Within Groups	13980625	75	186408.3			
Total	24354353	76				

When conducting a single factor ANOVA test, the p-value must be below .05 to reject the null hypothesis with statistical certainty. Since the p-value is extremely low we can reject the null hypothesis with an almost statistical certainty which confirm the difference in sample means. We can conclude that the Total Project Duration for a DB project is lower than the Total Project Duration for the DBB project, based on this sample.

5.1.2 Fiscal Year Duration

One may argue that the difference as given previously may be attributable to fiscal constraints. A DBB project's design may be completed well before Congress authorizes and approves the funding for the appropriate fiscal year thereby increasing the project duration. Since a DBB construction contract and DB project contract can not start until after the fiscal year begins, a second project duration was calculated. "Fiscal Year Duration" or "FY Duration" was calculated as the difference between the contract completion date and the beginning of the FY authorized (i.e. October 1, 1999 for FY2000 projects). Figure 15 and Figure 16 graphically show these durations.

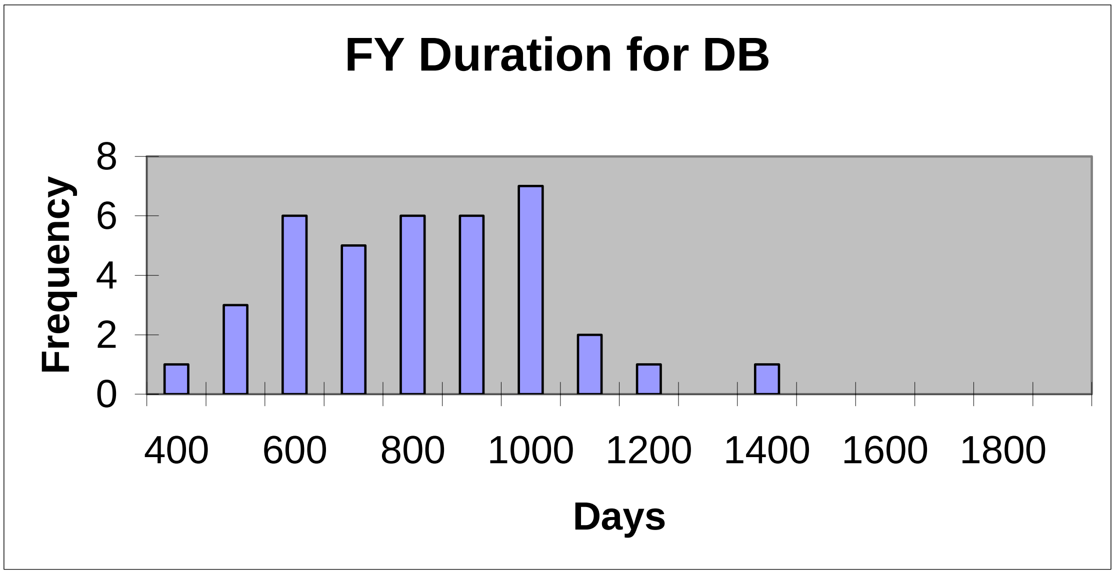

Figure 21: FY Duration for DB (N=38)

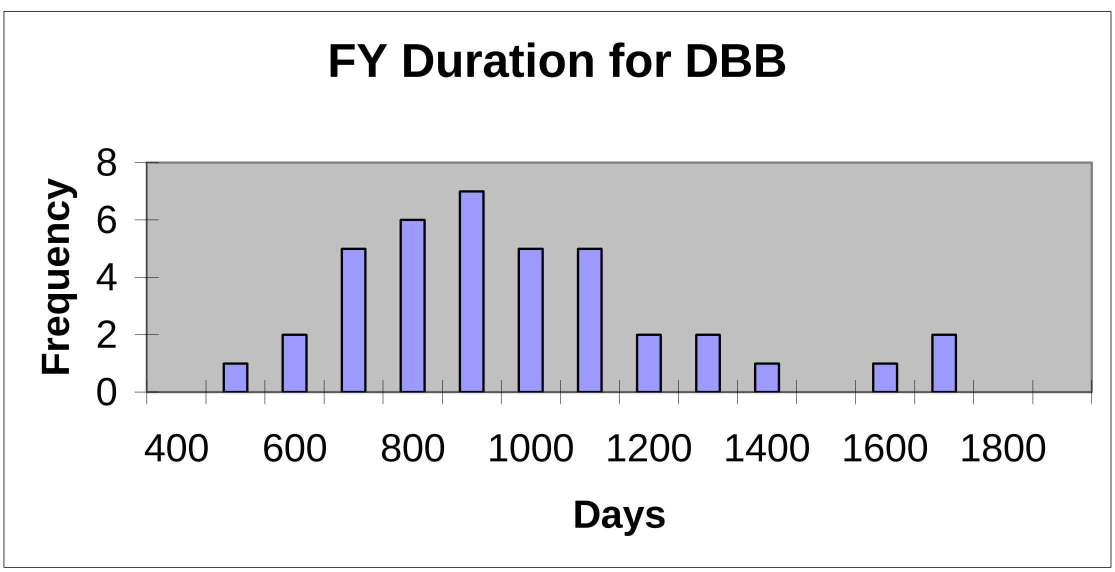

Figure 22: FY Duration for DBB(N=39)

The DB histogram (

Figure 21) is no longer as compact, although it is still more compact than the DBB histogram (

Figure 22). Several of the outlying projects that were greater than 2000 days in Figure 18 are now under 2000 days in

Figure 22. From the histogram it appears that the DB distribution is still skewed to the left as compared to DBB projects.

The FY Duration means and the medians for the two samples are much closer to the same (Figure 23, Figure 24 and Table 6). The difference in the means and medians are around 150 days which is about four times lower than the same difference in Total Project Duration (Table 4).

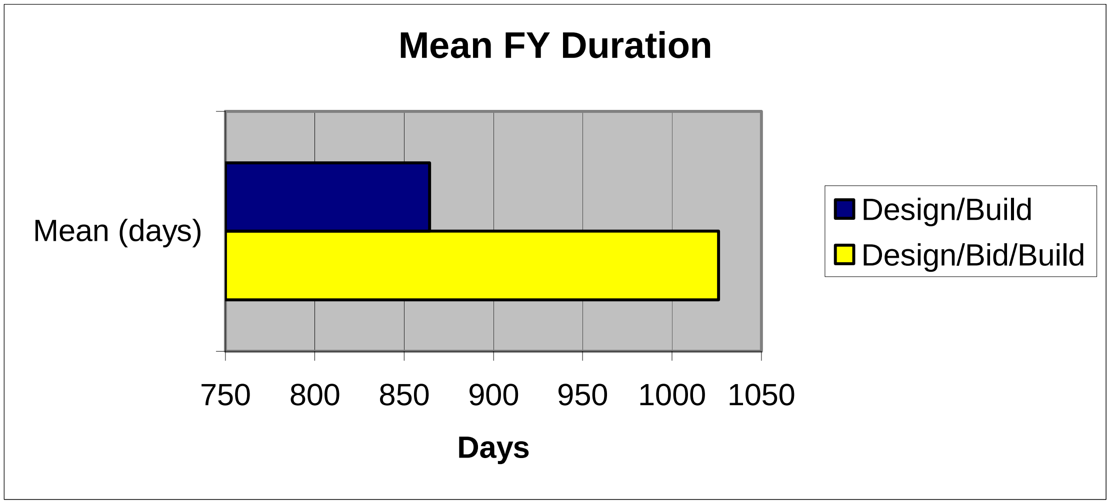

Figure 23: Mean FY Duration

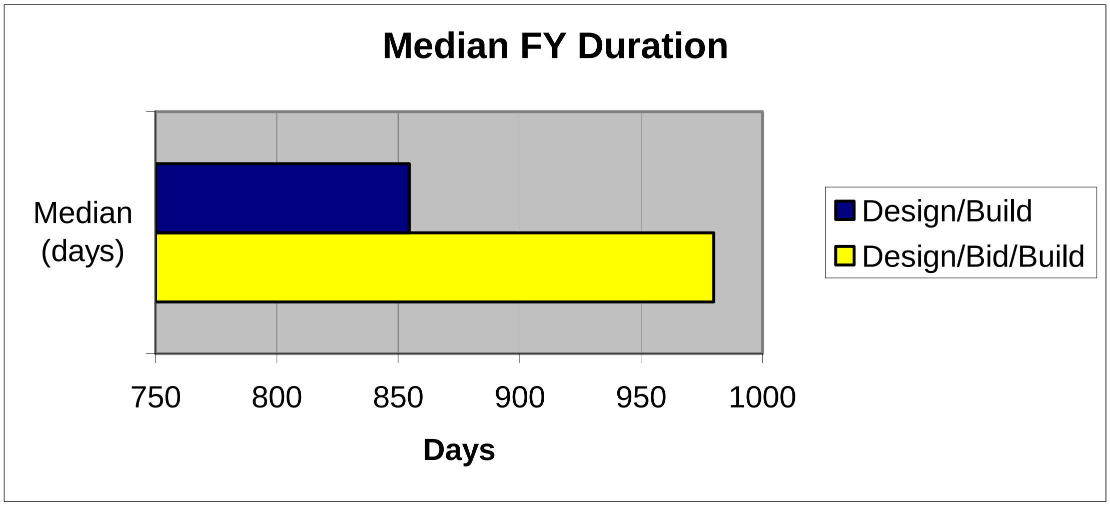

Figure 24: Mean FY Duration

Table 6: Statistics for FY Duration

	Design/Build	Design/Bid/Build
Number of Projects	38	39
Mean (days)	864	1026
Median (days)	855	980
Standard Deviation (days)	216	286

An analysis of variance (ANOVA) was conducted to determine if the means of the two samples were the same. The null hypothesis was that $\mu_{DB} = \mu_{DBB}$ where μ_{DB} = the mean FY Duration for the DB sample and μ_{DBB} = the mean FY Duration for the DBB sample.

Table 7 shows the results.

Table 7: Single Factor ANOVA for FY Duration

Groups	Count	Sum	Average	Variance
Design/Build	37	32116	868	47431.56
Design/Bid/Build	38	39523	1040.079	78288.89

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	555110.6	1	555110.6	8.801281	0.004067	3.972037
Within Groups	4604225	73	63071.57			
Total	5159335	74				

Since the P-value is 0.01 we can reject the null hypothesis with statistical certainty confirming the difference in sample means. We can conclude that even the FY Duration for a DB project will be lower than the FY duration for the DBB project.

5.1.3 Project/Construction Start Duration

Congress does not always approve and authorize the MILCON projects on or before the beginning of the fiscal year. So using the start of the fiscal year might skew the results since the number of projects in each sample is not the same in each fiscal year. Another duration was therefore calculated. This duration started at the first contract action after the beginning of the fiscal year. So the DB sample included both the time for design and construction where the DBB sample only included the time for construction. This duration will be referred to as Project/Construction or P/C Start Duration. Figure 15 and Figure 16 graphically show these durations.

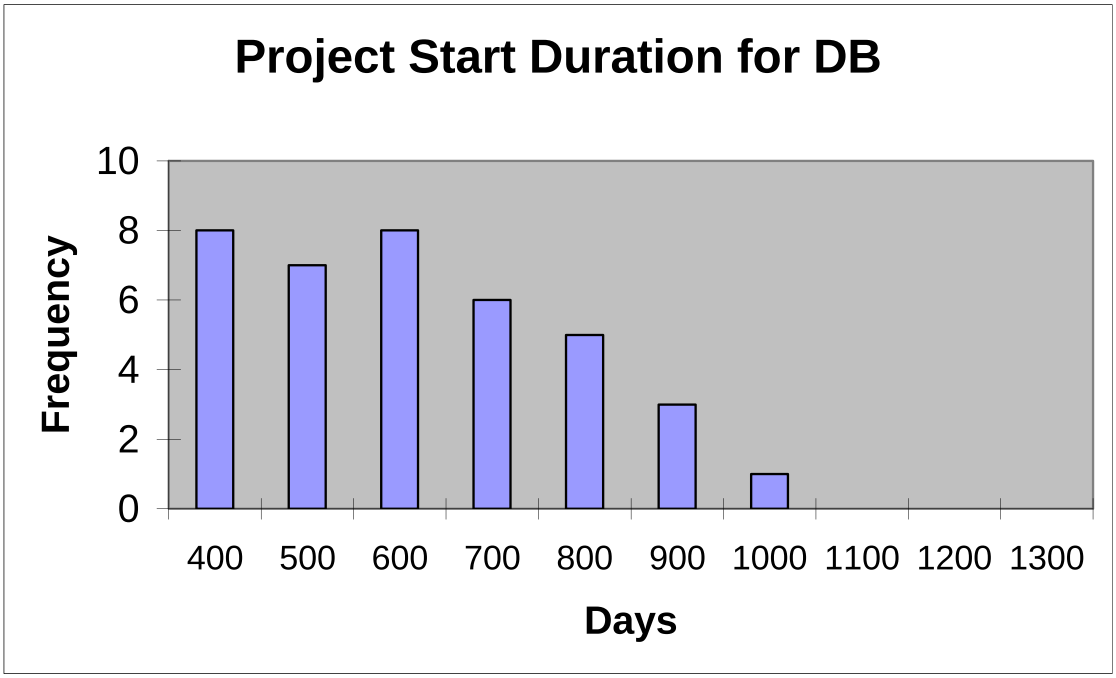

Figure 25: Histogram for Project Start Duration for DB (N=38)

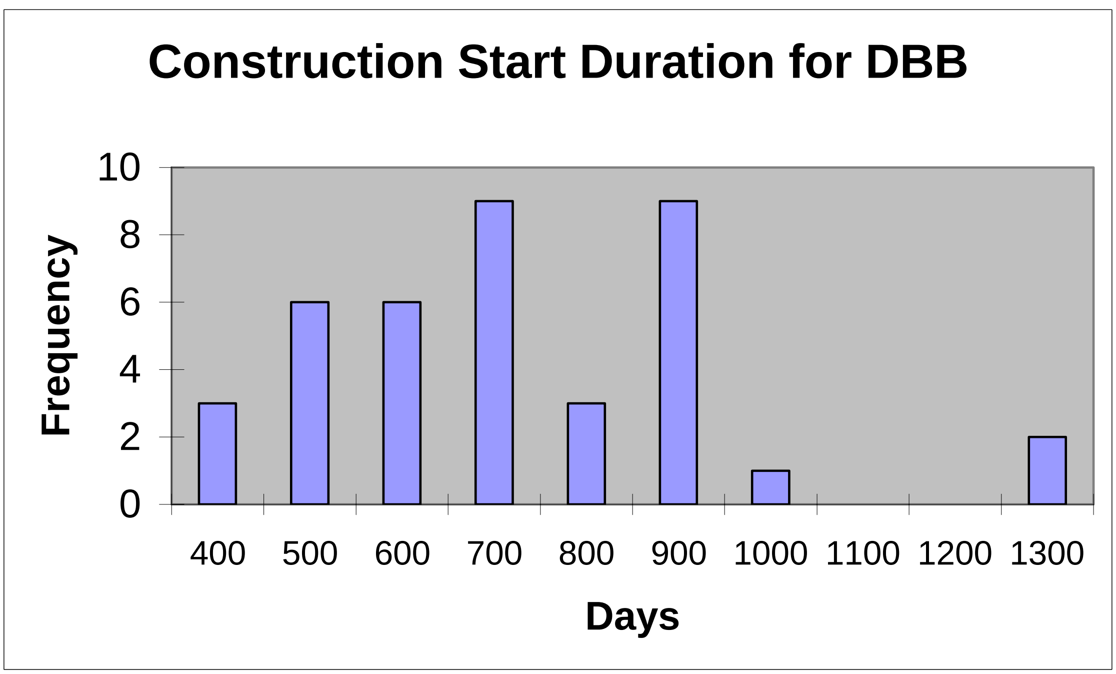

Figure 26: Construction Start Duration for DBB (N=39)

The histogram (Figure 25) is the same histogram as Figure 17 since the original comparison was based comparing the two samples' durations from the beginning of the design phase to project completion. As expected, the durations for the construction portions are more compact as shown in Figure 26, but still not as compact as Figure 25. Only one DBB project can be seen as quicker than any DB projects. This is somewhat unexpected since the DB contracts require both the *design* and the construction to be completed while the DBB contract is only for construction. The DBB histogram has more similar dispersion with only two projects outside of the 400 to 1100 range.

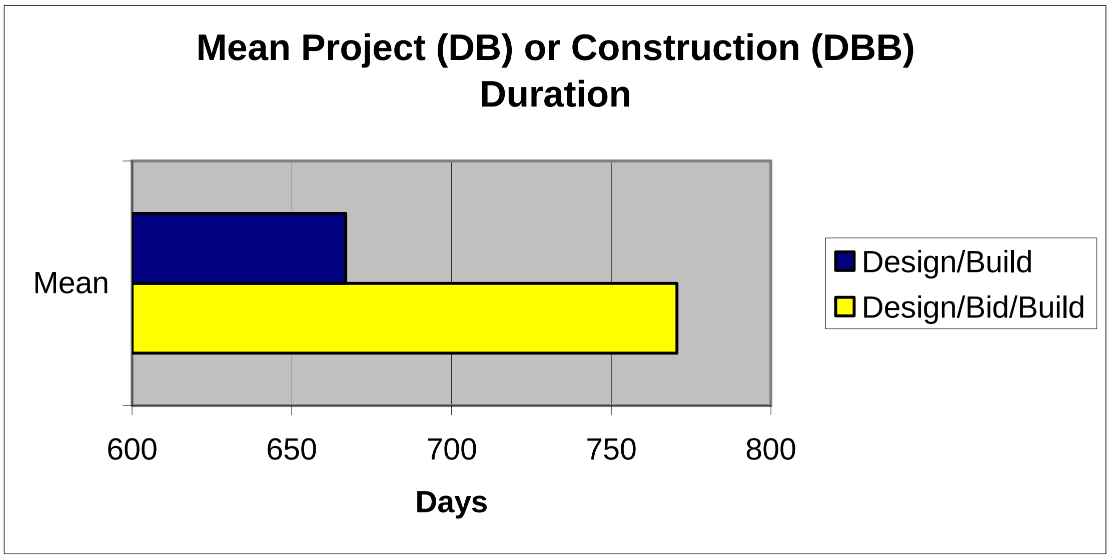

Figure 27: Mean Project or Construction Duration

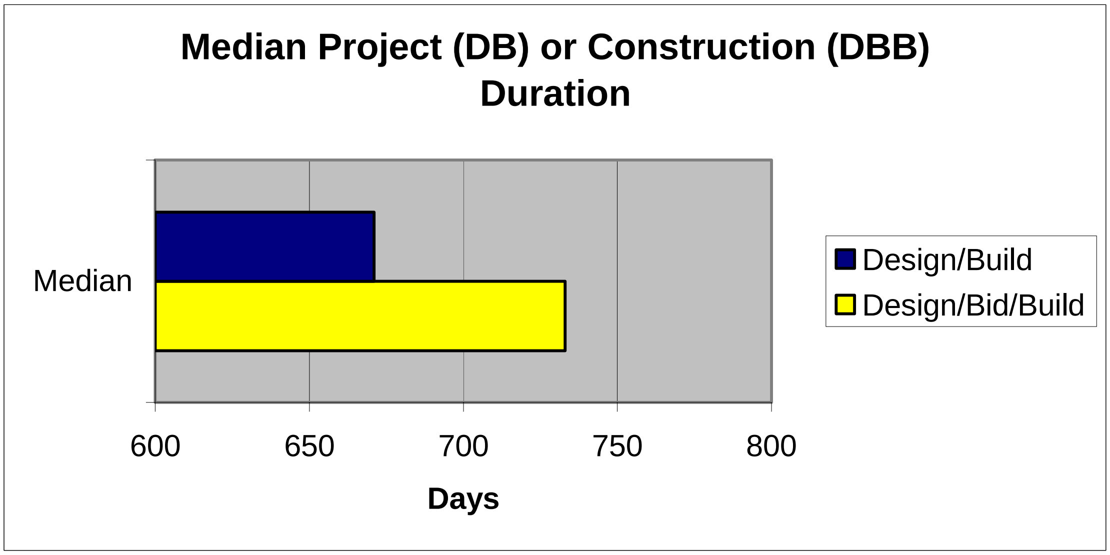

Figure 28: Median Project or Construction Duration

The means and medians for these two samples are more similar (Figure 27, Figure 28 and Table 8). The means are only different by 90 days and the median by 62 days. The samples still appear to have some variation, but are more similar than the previous two sets of samples.

Table 8: Statistics for Project/Construction Start Date

	Design/Build	Design/Bid/Build
Number of Projects	38	39
Mean (days)	667	771
Median (days)	671	733
Standard Deviation (days)	173	215

An analysis of variance (ANOVA) was conducted to determine if the means of the two samples were the same. The null hypothesis was that $\mu_{DB} = \mu_{DBB}$ where μ_{DB}

= the mean P/C Start Duration for the DB sample and μ_{DBB} = the mean P/C Start Duration for the DBB sample. Table 9 shows the results.

Table 9: Single Factor ANOVA for Project/Construction Start Duration

Groups	*Count*	*Sum*	*Average*	*Variance*
Design/Build	38	25342	666.8947	29842.26
Design/Bid/Build	39	30162	773.3846	45478.51

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	218260	1	218260	5.779483	0.018684	3.968471
Within Groups	2832347	75	37764.62			
Total	3050607	76				

The P-value is 0.02 so we can reject the null hypothesis with statistical certainty that no difference exists in samples' means. We can conclude that the Project/Construction Start Duration for a DB project is faster than the Project/Construction Duration for the DBB project for this sample.

5.2 Time per Bed

Each BEQ project had a unique number of beds. The above durations only take into account the total duration irrespective of the size of projects. An even more accurate comparison of total time may be to compare average project time per bed for each sub-sample.

5.2.1 Total Project Duration

Figure 29 and Figure 30 show the histograms for the days/bed for DB and DBB for Total Project Duration. The duration histogram (Figure 29) shows a well-grouped cluster of projects for DB. Figure 29 brings to light the fact that one of the projects took about twice the time per bed that even the second highest time per bed. This project (DB-1) only constructed a facility with 40 beds (11.75 days/bed). The sample used in Figure 29 and Figure 30 included all 77 sample projects and only three other projects had fewer than 100 beds (DB-15 had 90 beds, DBB-5 had 96 beds, and DBB-14 had 72 beds). These projects have time/bed ratios of 5.38, 7.98 and 14 days/bed). Furthermore Table 10 shows that the average number of beds was 329 and 275 for DB and DBB respectively. Economy of scale probably caused this unusual data point. As will be discussed later, DB-1 completed on time. The histogram for DBB shows a much wider dispersion. The highest two values are 17.82 and 30.38 days/bed for DBB-32 and DBB-37. Both had long project durations, but more typical FY Durations and P/C Durations. This most likely indicates that the design was completed in anticipation of project approval and authorization by Congress, but Congress did not approve and authorize the project until future years.

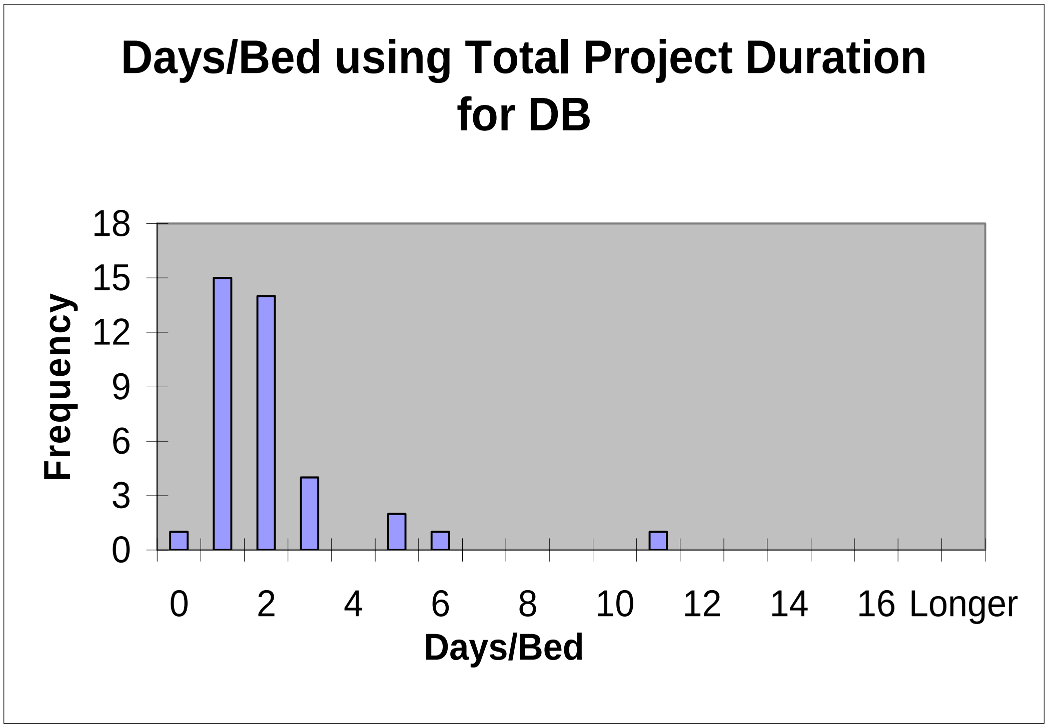

Figure 29: Histogram for Time/Bed for DB (N=38)

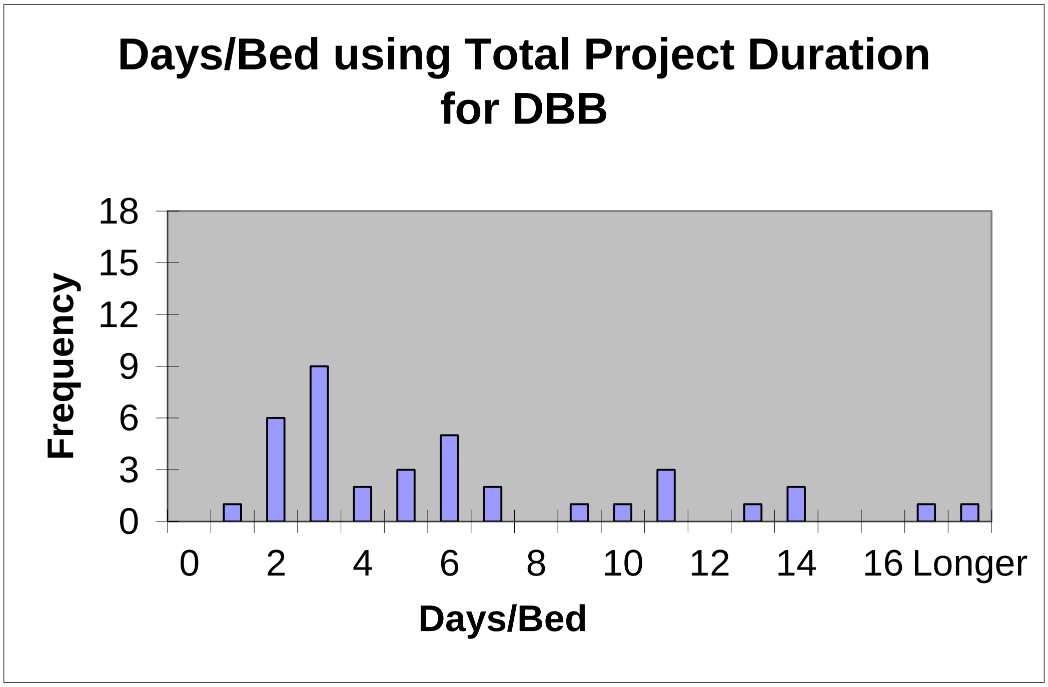

Figure 30: Histogram for Days/Bed using Total Project Duration for DBB (N=39)

Figure 31, Figure 32 and Table 10 show that the mean, median, and standard deviation for the DBB sub-sample are much larger than the corresponding values for DB.

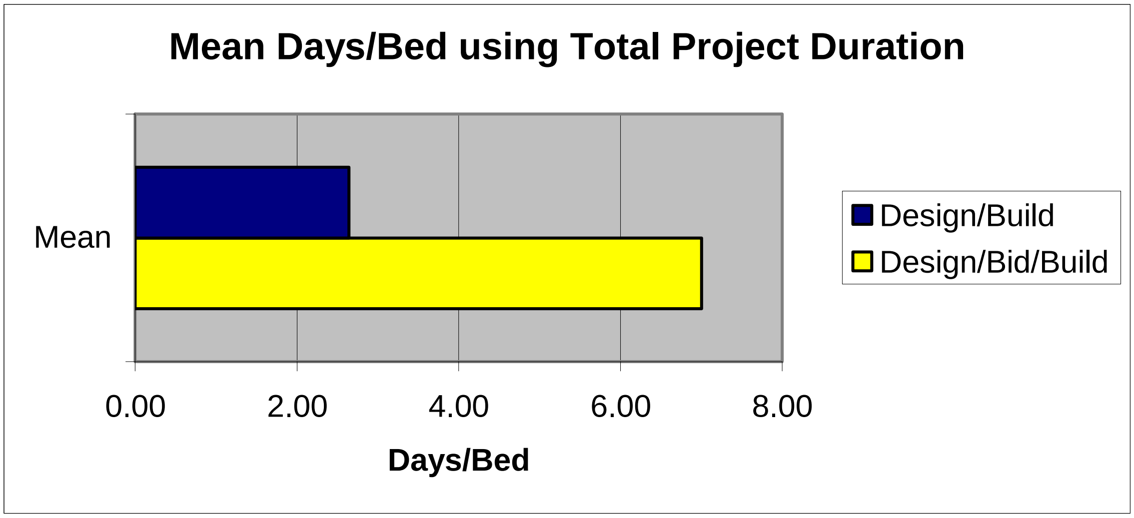

Figure 31: Mean Time/Bed using Total Project Duration

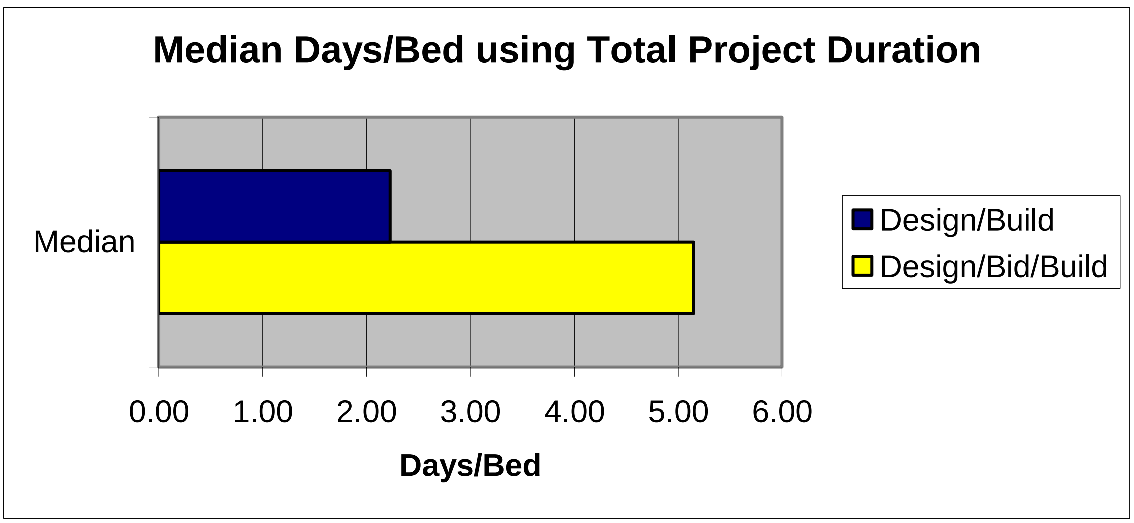

Figure 32: Median Time/Bed using Total Project Duration

Table 10: Statistics for Days/Bed using Total Project Time

	Design/Build	Design/Bid/Build
Number of Projects	38	39
Mean (days/bed)	2.64	7.00
Median (days/bed)	2.23	5.15
Standard Deviation (days/bed)	1.94	5.60

An analysis of variance (ANOVA) was conducted to determine if the means of the two samples were the same. The null hypothesis was that $\mu_{DB} = \mu_{DBB}$ where μ_{DB} = the mean days/bed for the DB sample and μ_{DBB} = the mean days/bed for the DBB sample. Table 11 shows the results.

Table 11: Single Factor ANOVA for Days/Bed using Total Project Duration

Groups	*Count*	*Sum*	*Average*	*Variance*
Design/Build	38	100.4322	2.642953	3.762905
Design/Bid/Build	39	273.4301	7.011028	31.30648

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	367.2295	1	367.2295	20.72598	2.01E-05	3.968471
Within Groups	1328.874	75	17.71832			
Total	1696.103	76				

Similar to the results shown in

Table 5 for Project Duration, the P-value is virtually zero which shows with virtual certainty that the null hypothesis is not true and the sub-samples' means are not the same. It can be concluded that the days/bed for a DB project are lower than the days/bed for a DBB project for this sample.

5.2.2 Fiscal Year Duration

A similar analysis of Days/bed using FY Duration was conducted as given in this section. Figure 33 and Figure 34 display the distributions for days/bed using FY Duration. Figure 33 shows that the DB projects are tightly grouped between zero and ten days/bed with only one project duration greater than ten. Figure 34 shows a much wider distribution for the DBB projects with most of the projects between one and eighteen days/bed.

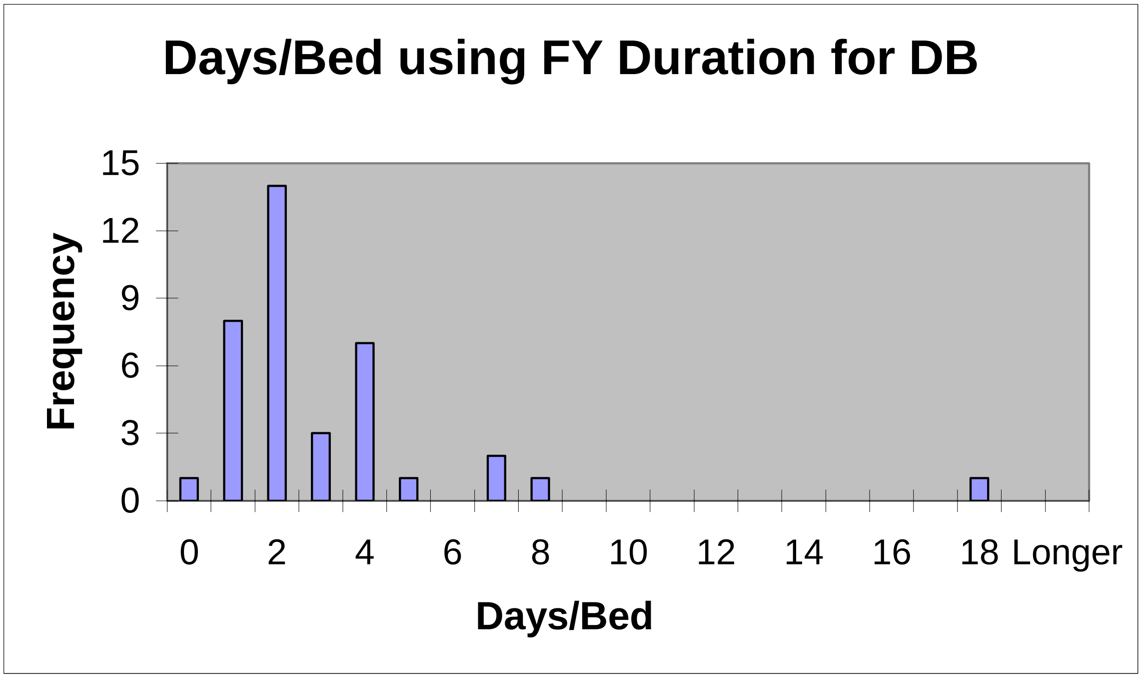

Figure 33: Histogram for Days/bed using FY Duration for DB (N=38)

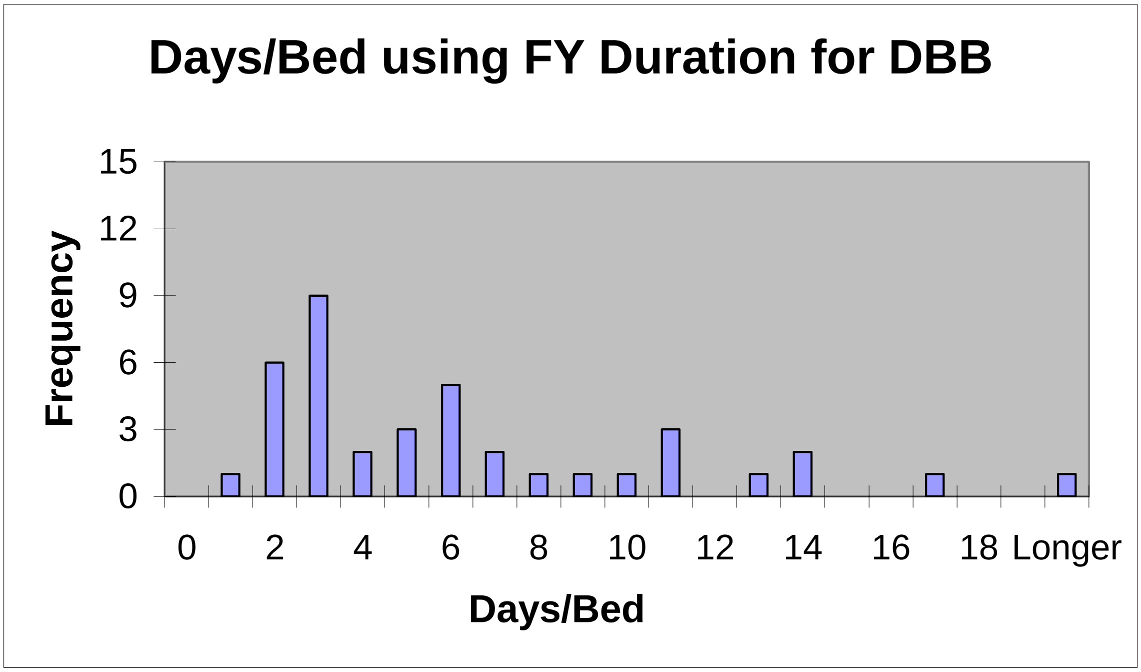

Figure 34: Histogram for Days/Bed using FY Duration for DBB (N=39)

Figure 35, Figure 36 and Table 12 show the mean and median for days/bed using FY Duration. The difference between the two samples' mean and median for days/bed is actually greater, on a percentage basis, than the difference between them for FY Duration. This indicates that the difference between these metrics are greater when the projects are normalized for the number of beds in the projects.

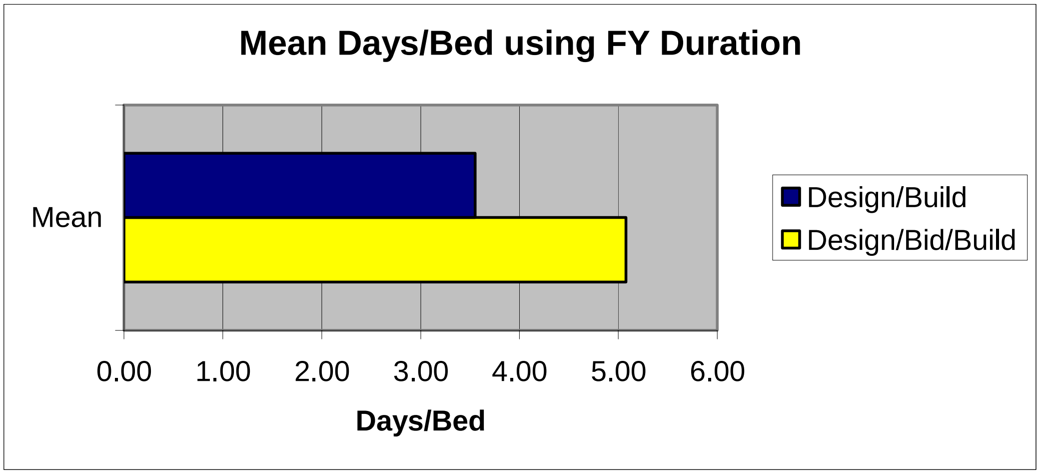

Figure 35: Mean Days/Bed using FY Duration

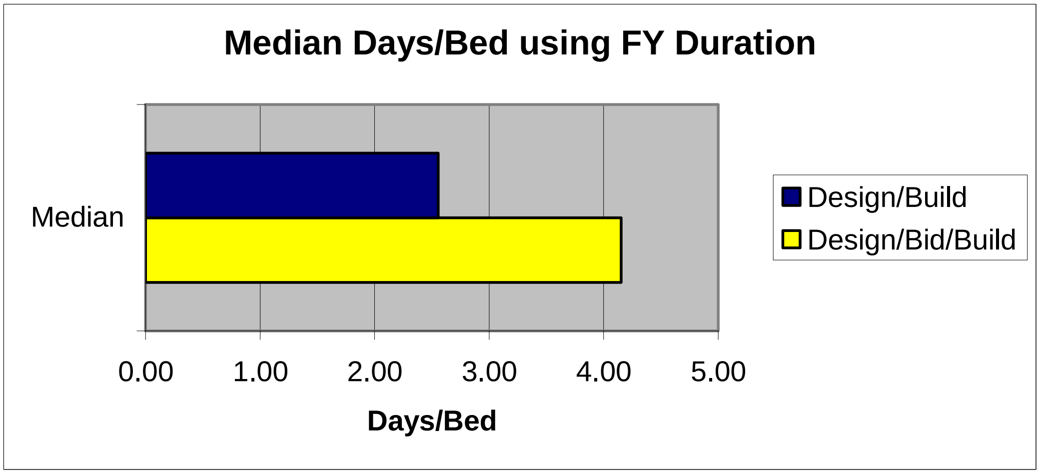

Figure 36: Median Days/Bed using FY Duration

Table 12: Statistics for Days/Bed using FY Duration

	Design/Build	Design/Bid/Build
Number of Projects	38	39
Mean (days/bed)	3.55	5.08
Median (days/bed)	2.55	4.15
Standard Deviation (days/bed)	3.00	3.43

An analysis of variance (ANOVA) was conducted to determine if the means of the two samples were the same. The null hypothesis was that $\mu_{DB} = \mu_{DBB}$ where μ_{DB} = the mean days/bed using FY Duration for the DB sample and μ_{DBB} = the mean days/bed using FY Duration for the DBB sample. Table 13 shows the results.

Table 13: Single Factor ANOVA for Days/Bed using FY Duration

Groups	*Count*	*Sum*	*Average*	*Variance*
Design/Build	38	134.9301	3.550791	8.988248
Design/Bid/Build	39	198.3509	5.08592	11.71031

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	45.35728	1	45.35728	4.37498	0.039856	3.968471
Within Groups	777.5569	75	10.36743			
Total	822.9142	76				

The P-value is 0.04 so we can reject the null hypothesis with statistical certainty that sub-samples' means are the same. We may conclude that the Days/bed using FY

Duration for a DB project is lower than the Days/bed using FY Duration for a DBB project for this sample.

5.2.3 Project/Construction Start Duration

An analysis of days/bed using P/C Start Duration was conducted as given in this section. Similar to the other histograms related to time, Figure 37 and Figure 38 show a wider distribution for the DBB projects.

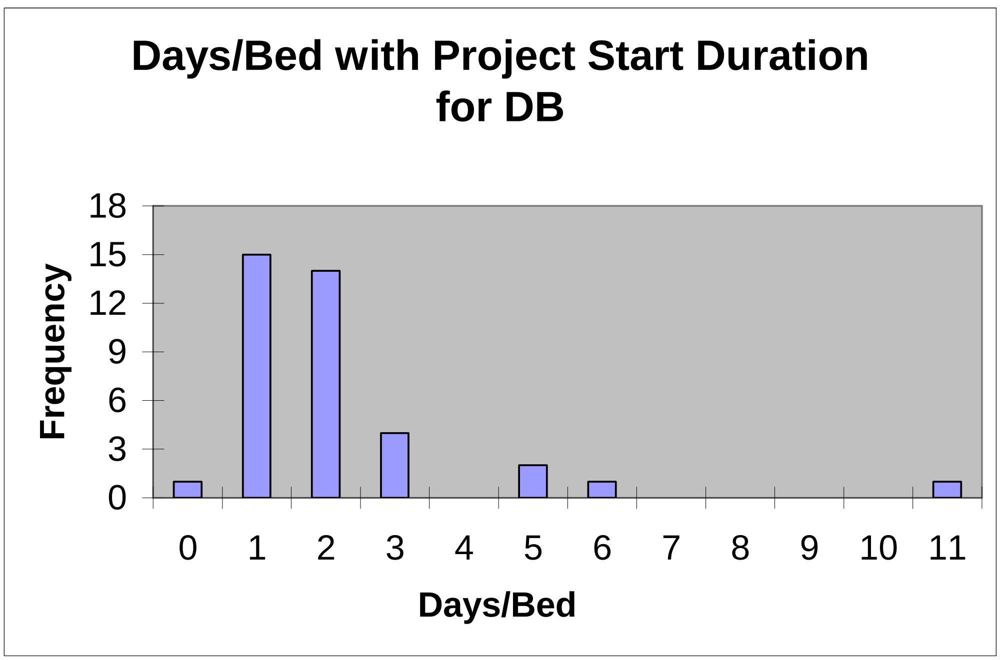

Figure 37: Histogram for Days/Bed with Project Start Duration for DB (N=38)

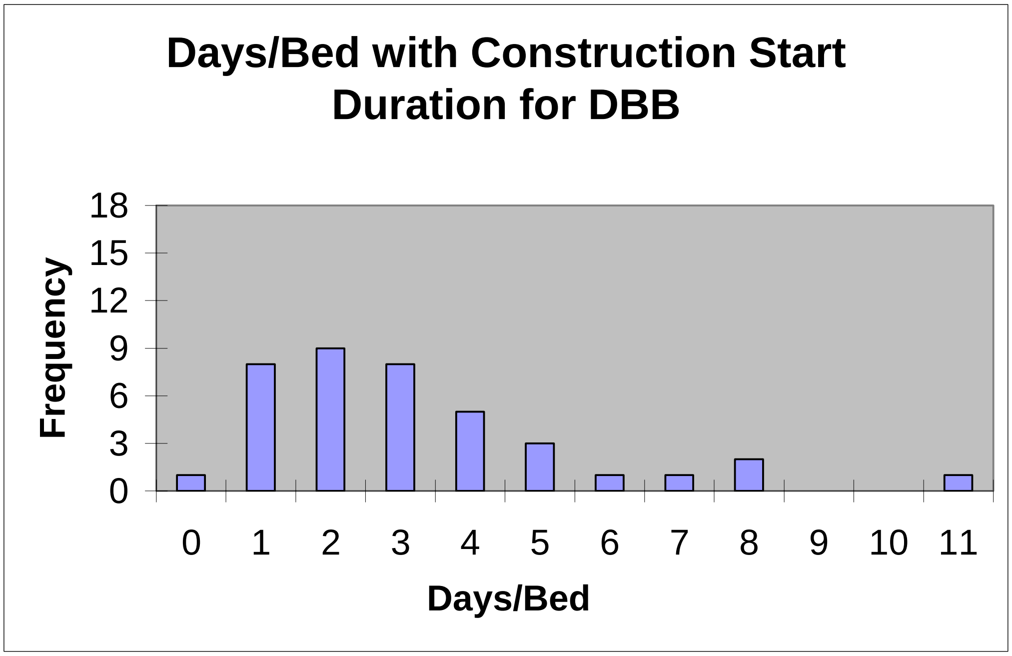

Figure 38: Histogram for Days/Bed with Construction Start Duration for DBB (N=39)

Figure 39, Figure 40 and Table 14 show the mean, median and standard deviation. Again the mean and median of the sub-samples are less for the DB projects, even though the DB projects include both design and construction.

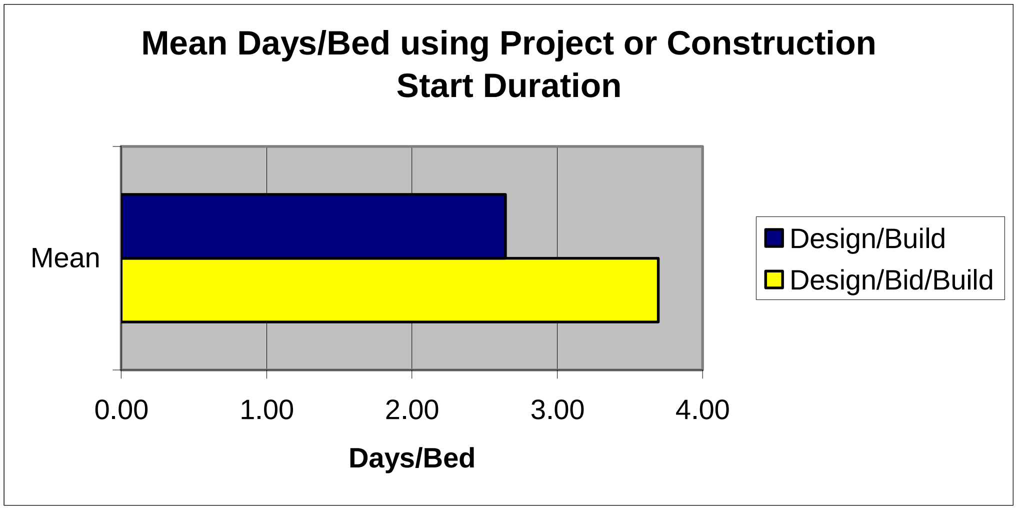

Figure 39: Mean Days/Bed using Project or Construction Start Duration

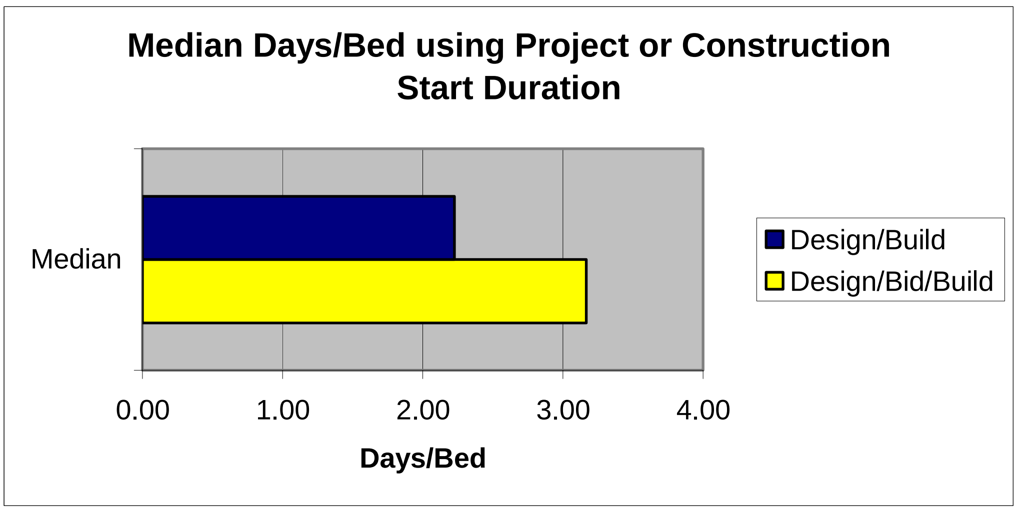

Figure 40: Median Days/Bed using Project or Construction Start Duration

Table 14: Statistics for Days/bed using Project/Construction Duration

	Design/Build	Design/Bid/Build
Number of Projects	38	39
Mean (days)	2.64	3.70
Median (days)	2.23	3.17
Standard Deviation (days)	1.94	2.34

An analysis of variance (ANOVA) was conducted to determine if the means of the two samples were the same. The null hypothesis was that $\mu_{DB} = \mu_{DBB}$ where μ_{DB} = the mean days/bed using Project Start Duration for the DB sample and μ_{DBB} = the mean days/bed using Construction Start Duration for the DBB sample. Table 15 shows the results.

Table 15: Single Factor ANOVA for Days/Bed using Project/Construction Start Duration

Groups	*Count*	*Sum*	*Average*	*Variance*
Design/Build	38	100.4322	2.642953	3.762905
Design/Bid/Build	39	144.5152	3.705517	5.439211

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	21.73038	1	21.73038	4.711466	0.033127	3.968471
Within Groups	345.9175	75	4.612233			
Total	367.6479	76				

The P-value is 0.03 so we can reject the null hypothesis with statistical certainty that no difference exists in sub-samples' means. We may conclude that the days/bed using Project/Construction Start Duration for a DB project is lower than the Days/bed using Project/Construction Start Duration for the DBB project for this sample. This shows that DB delivers the project faster even than the construction phase of DBB projects.

One possible explanation for this noteworthy discrepancy might be related to contract duration. The DBB projects may be giving the construction contractor more time than needed to complete the contract. Many times BEQ's will be awarded to the lowest bidder. When this contract mechanism is used, the construction contractor does not submit any other information except cost. DB projects must be selected based on a variety of factors including cost. More leeway is allowed in the proposals so that a DB contractor could reduce the number of days in their proposal in an effort to be selected. The construction duration would therefore be shorter and make the whole contract shorter.

5.3 Time Growth

All construction contracts have targeted completion dates. Both the owner and the constructor want the projects to finish on or before this completion date. The owner benefits greatly from this predictability. The owner can plan installation of non-construction related equipment and begin use of the building sooner. Delays to completion also cost the owner money in some circumstances. The contractor will request extra money based on having the personnel and equipment on site longer than the original contract requirement if it is the owner's fault. The time that the owner will not be able to use the facility is also costly.

The constructor wants to finish the project on time or early for various reasons. If a project finishes early, the constructor can put his forces to work in other places sooner and delivers the cash flow quicker. Finishing early or on time also improves their reputation which could lead to more jobs in the future. As future work is planned and bid for, knowing with some degree of certainty the completion is important to maximize their resources and reduces direct job overhead costs such as supervisor, job site trailer costs, etc.

Establishing time growth for projects based on project delivery method is important to both parties. Due to the great variation in average duration of the two samples, the number of days of time growth was evaluated instead of the percentage of time growth.

The histograms for the time growth in days are shown in **Figure 41** and Figure 42. The two samples clearly have two different distributions. **Figure 41** shows that more than half of the DB projects had time growths of less than 100 days and most projects had less than 300 days of time growth. Conversely Figure 42 shows a much wider distribution for DBB. Several DBB projects had greater than 350 days of time growth.

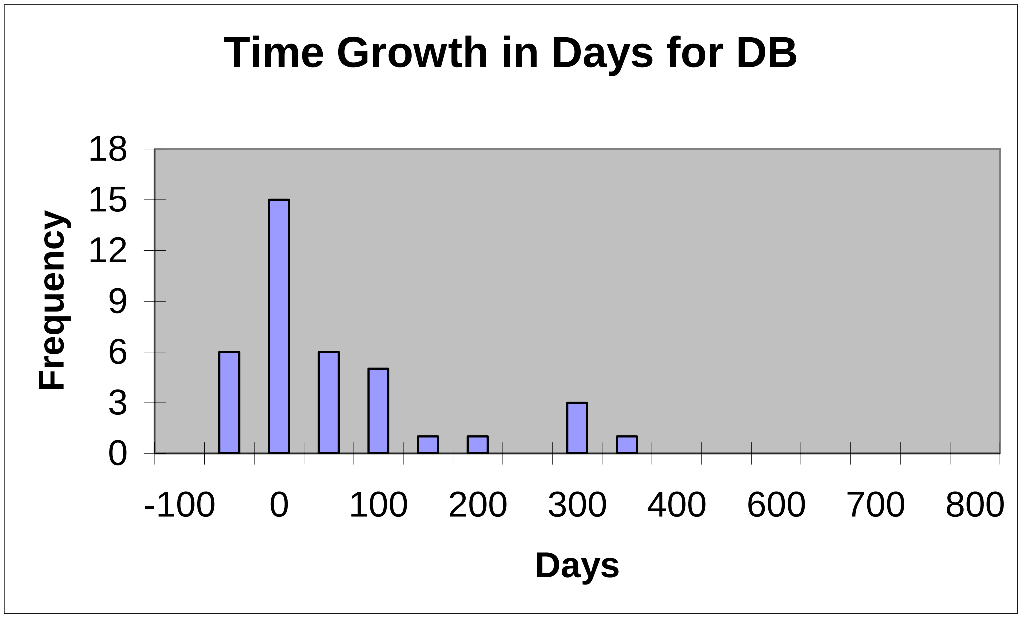

Figure 41: Time Growth for DB (N=38)

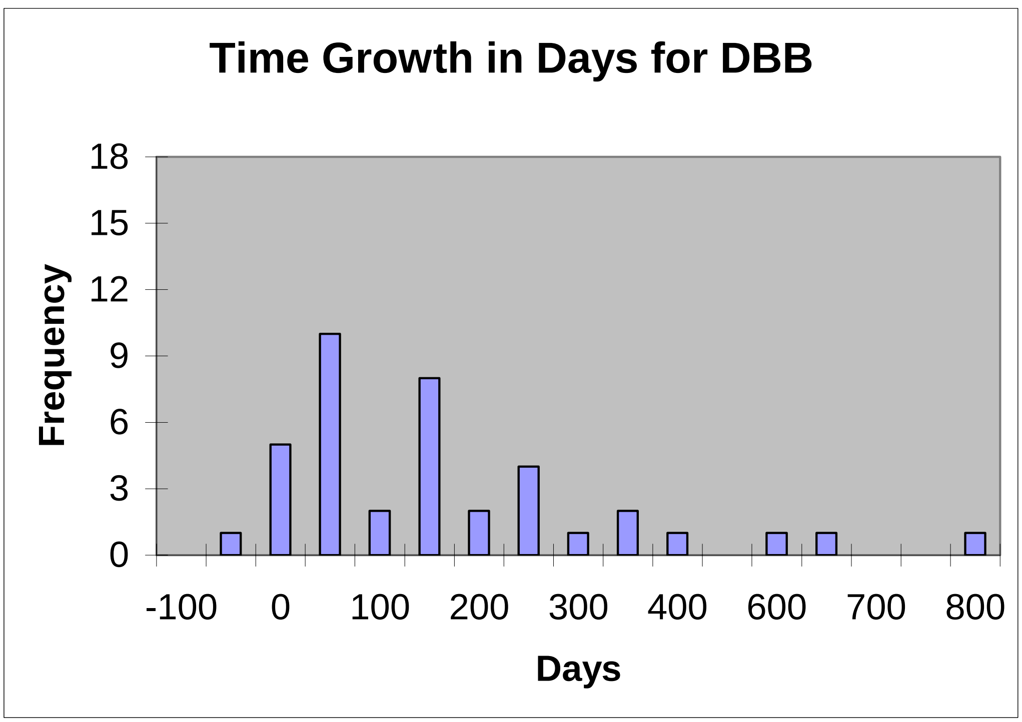

Figure 42: Time Growth for DBB (N=39)

The statistics show a similar disparity between the two samples (Figure 43, Figure 44 and Table 15). The mean for DBB is more than double the mean for DB. The median for DBB is more than triple the median for DB.

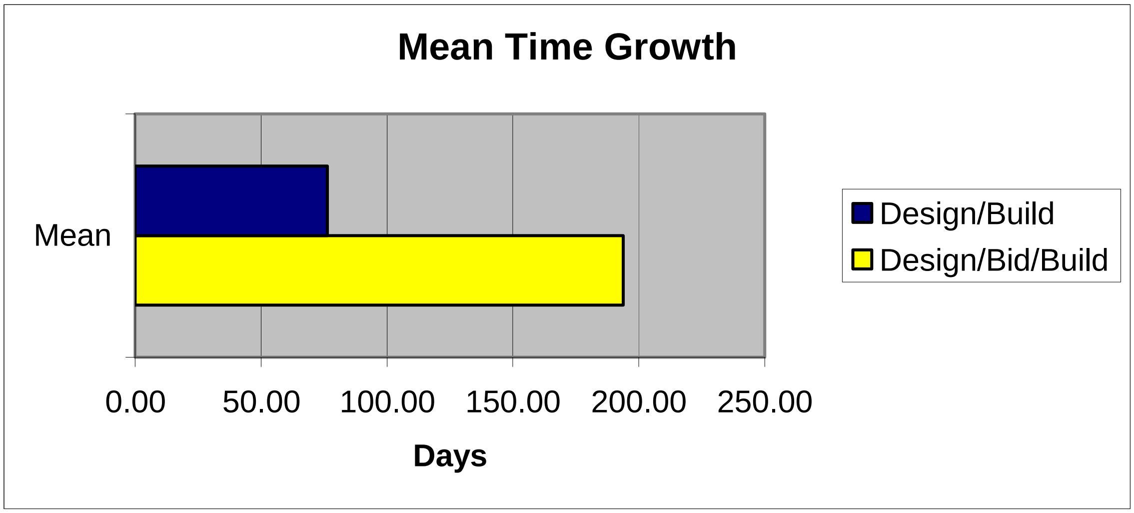

Figure 43: Median Time Growth

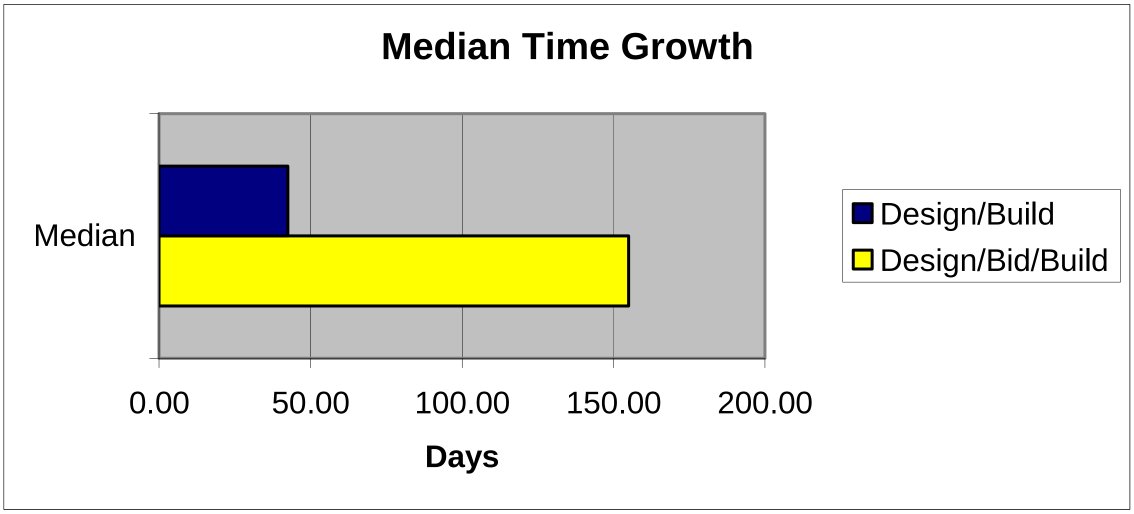

Figure 44: Median Time Growth

Table 16: Statistics for Time Growth

	Design/Build	Design/Bid/Build
Number of Projects	38	39
Mean (days)	76.39	193.85
Median (days)	42.50	155.00
Standard Deviation (days)	114.57	189.23

An analysis of variance (ANOVA) was conducted to determine if the means of the two samples were the same. The null hypothesis was that $\mu_{DB} = \mu_{DBB}$ where μ_{DB} = the mean time growth for the DB sample and μ_{DBB} = the mean time growth for the DBB sample. Table 17 shows the results.

Table 17: Single Factor ANOVA for Time Growth

Groups	*Count*	*Sum*	*Average*	*Variance*
Design/Build	38	2903	76.394737	13126.353
Design/Bid/Build	39	7671	196.69231	35230.166

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	278529.496	1	278529.5	11.450048	0.00114	3.96847
Within Groups	1824421.39	75	24325.618			
Total	2102950.88	76				

The p-value is less than 0.01 which means that we can reject the null hypothesis with 99% certainty in concluding that the samples' means are most likely not the same. The time growth for a DB project is lower than the time growth for the DBB project for this sample.

One possible explanation for this difference could be that one EFD/EFA is more likely to have a significant time growth due to the personnel administering the contract or the contractors that are executing the projects. Figure 45 shows a histogram comparing the average time growth for the DB and DBB projects by EFD/EFA. EFA North only had one DB project and it completed 71 days early. EFA Northwest and EFD Pacific did not have any DB projects. The DBB projects in EFA Northwest and EFA Chesapeake had no time growth. Although EFA Southwest has a comparatively large average time growth for its DBB projects, the average time growth for its DB projects are comparable to the other EFD/EFA's. It does not appear that the EFD/EFA has a significant impact on time growth.

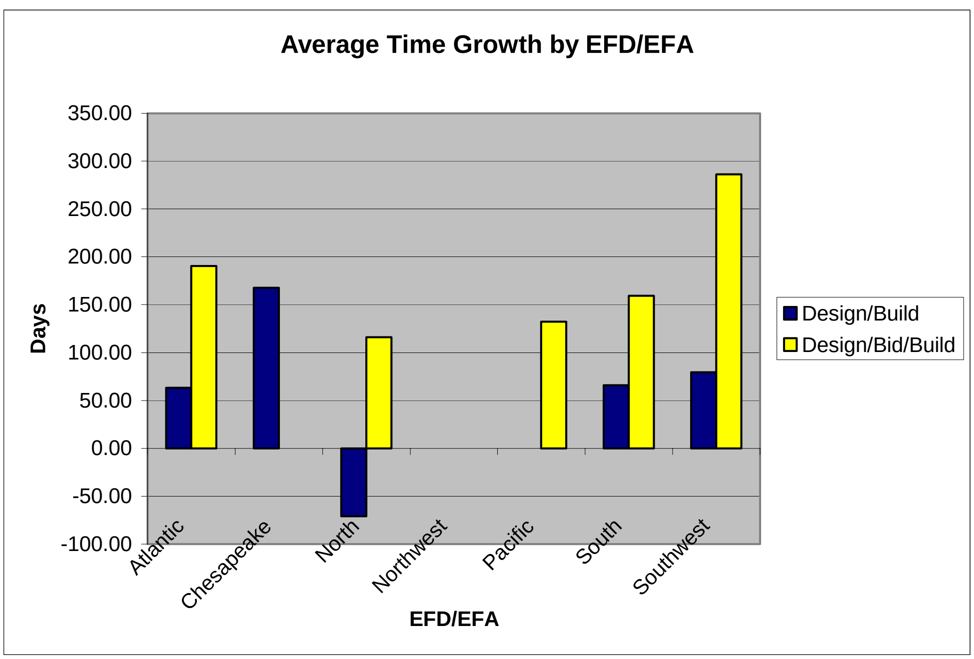

Figure 45: Average Time Growth by EFD/EFA

5.4 Cost/Bed with Other Costs

Since cost is always a consideration when determining which project delivery method to use, the cost per bed is an important metric to consider. Since both samples have a wide range of beds, the cost per bed was used to normalize the data in order to see if one method was more cost efficient than the other. This data is equivalent to analyzing the cost per square foot since project total square footage is based upon the number of beds in the facility.

For 52 of the 77 projects, the total project cost also included costs that did not directly relate to the construction of the BEQ (Figure 46). These costs needed to be removed to accurately compare projects with non-construction costs to projects without these extra costs. These costs were broken down into two groups—demolition and "other costs". Demolition costs were included in 50 of these projects. The projects demolished anywhere from one to eleven buildings. "Other costs" included a variety of unusual costs that needed to be removed to accurately obtain a cost per bed. This category included costs for construction of separate facilities such as mess halls, gymnasiums and parking structures. Other examples include environmental mitigation, special architectural features to match surrounding buildings, and dewatering. Four projects had "other costs," but no demolition costs. Five of the fifty demolition projects had both demolition and "other costs."

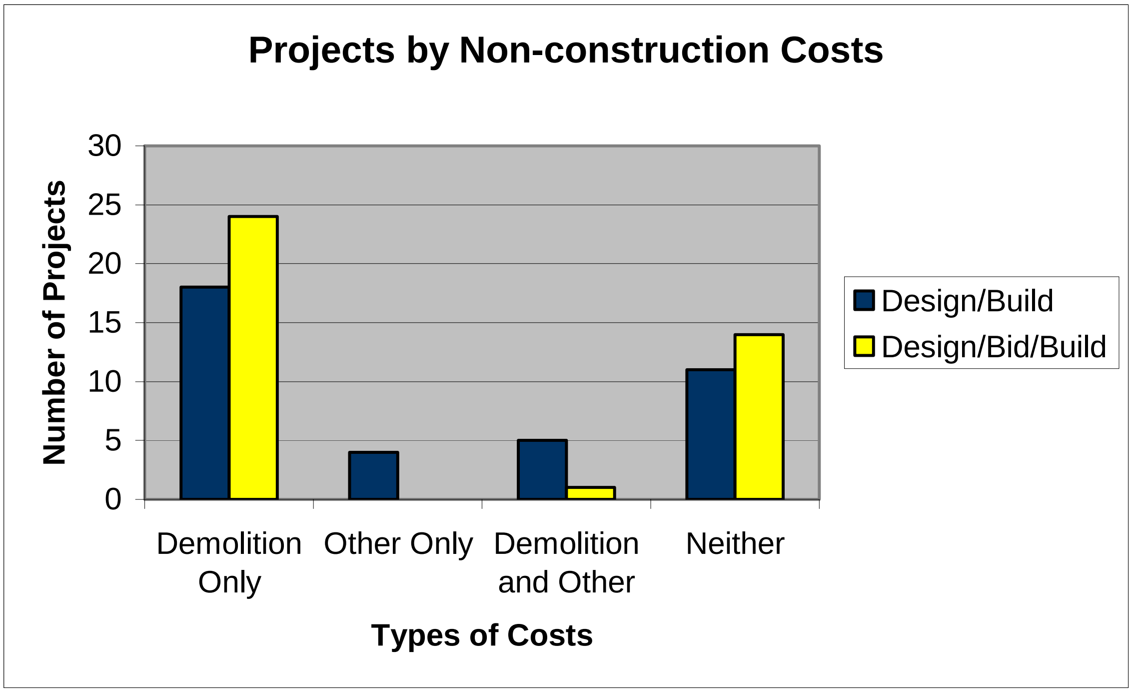

Figure 46: Non-construction costs

The actual costs for the demolition and the "other costs" were impossible to obtain since all of the contracts were lump sum contracts. Since the DD Form 1391's provided estimates for total construction cost, demolition and other costs, they were used to eliminate the non-construction costs. Thirty-nine of the forty-eight demolition projects had line items specifically for demolition. The ten projects that either had demolition and "other costs" or only "other costs" had separate line items for these costs. For these 49 projects that had separate line items for demolition and/or "other costs", the author determined what percent of the DD Form 1391 estimate that these non-construction costs made up. This percentage of the total estimate was removed from the total project cost to obtain an adjusted total barracks project cost.

Nine projects had demolition included in a line item with site improvement and paving. A methodology was developed to determine how much of the total project cost could be attributed to demolition. The DD Form 1391's for the entire data set were reviewed to establish a demolition cost per building. Twenty projects were found to have a separate line item for the cost of demolition and indicated the number of buildings to be demolished. The cost per building for demolition was calculated for each of these buildings. Then the nine projects that needed demolition costs were compared to the twenty projects that had demolition costs per building to see if any projects were on the same military base. One project was found to be on the same base. The demolition cost per building for the known project (DBB-22) was used for the associated unknown project (DBB-19).

The same method as above was used, but instead of comparing the projects that had inconclusive demolition costs to projects that were only in the same base the criteria was expanded to include projects within the same area. Average demolition costs per building were established as shown in Table 18. These values were verified that they were not higher than the original line item and were used to determine the demolition cost for 2 projects (DBB-15 and DBB-21). If these values were greater or nearly greater than the line item for demolition, paving and site improvements or if projects did not have any projects with demolition costs in the same state, the average demolition cost per building for all projects was used. This value was used for the demolition cost for one project. If this value was greater or nearly greater than the line item that included demolition or the DD Form 1391 did not indicate the number of buildings to be demolished, then 2/3 of the total for that line item was attributed to demolition. This method was used for the remaining five projects to obtain the adjusted total barracks project cost.

Table 18: Project Demolition Costs by Area

Location	Sample size	Demolition cost per bldg	Number of projects applied to
Virgina	4	328	1
California	8	147	0
North Carolina/South Carolina	2	105	0
Hawaii	2	313	1
Overall	20	174	1

This section describes the cost/bed with these other costs included. Section 5.6 will discuss the cost/bed without these other costs.

Frequency histograms using bins of $20,000 for Cost/bed with Other Costs are shown in

Figure 47 and

Figure 48. Both histograms appear to have normal distributions. The peak of the DB histogram is in the $60,000 to $80,000 range whereas the peak for the DBB is in the $80,000 to $100,000 range. DB shows a somewhat continuous distribution. DBB has some cost/bed that are as high as the $160,000 to $200,000 range.

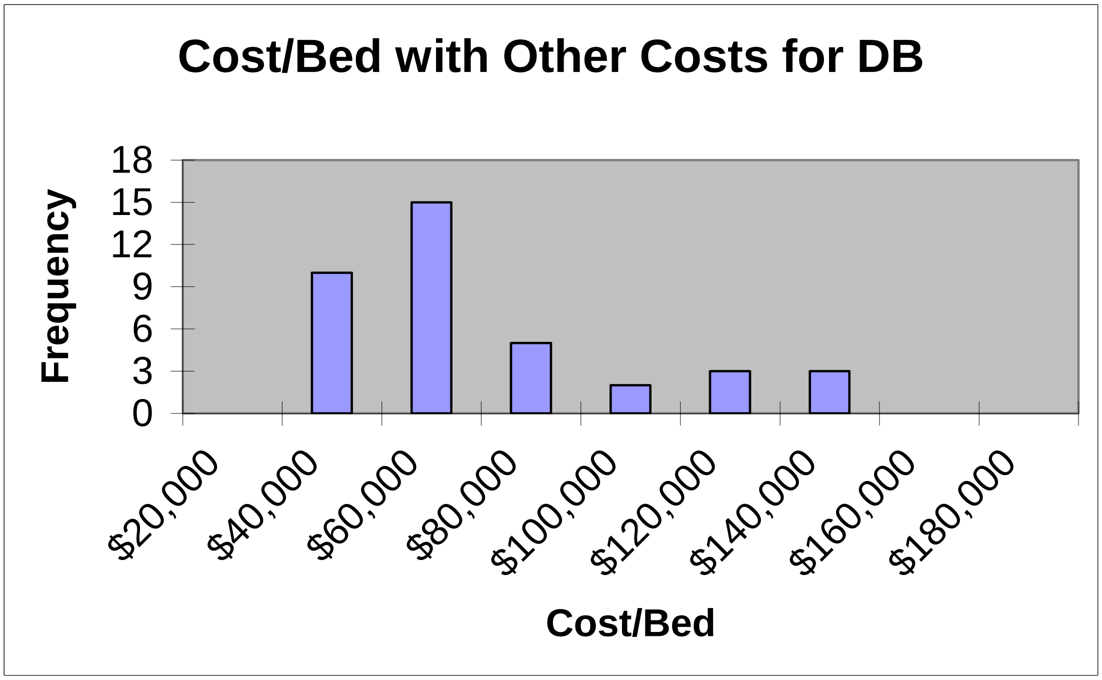

Figure 47: Cost/Bed with Other Costs for DB (N=38)

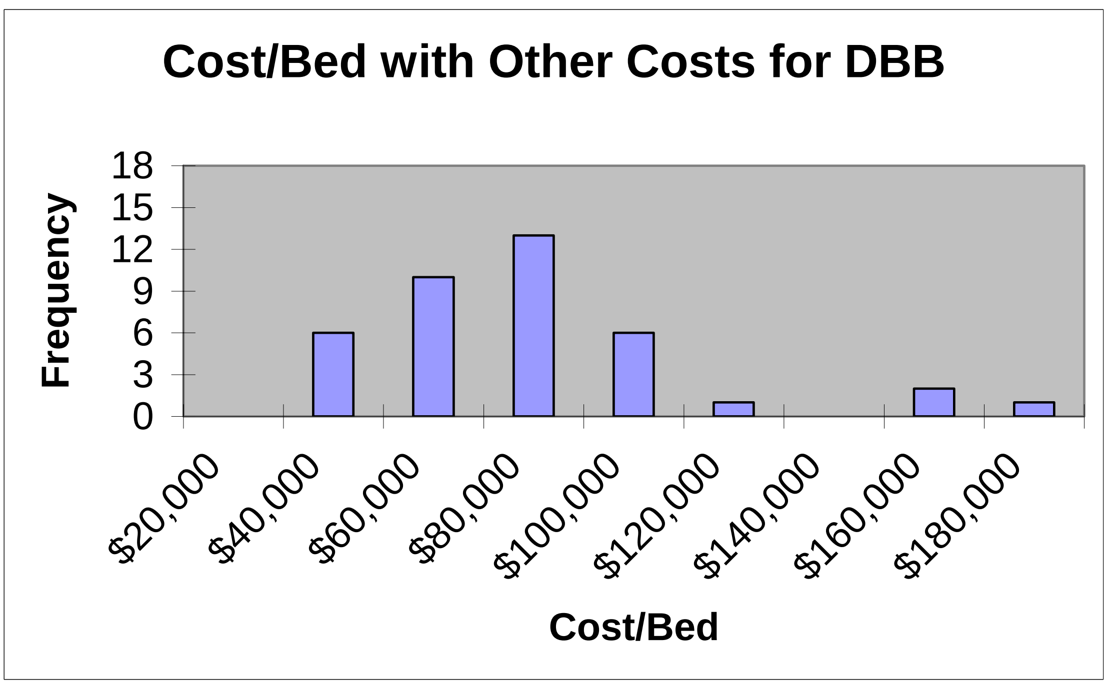

Figure 48: Cost/Bed with Other Costs for DBB (N=39)

Figure 49,

Figure 50 and Table 19 show the mean and median for Cost/Bed with Other Costs. The average values for DB is about $10,000 less than DBB (about 15%). The median value shows a little more disparity. The median DB project is about $13,000 less than the median DBB project or about 25%. The standard deviations for both samples are similar.

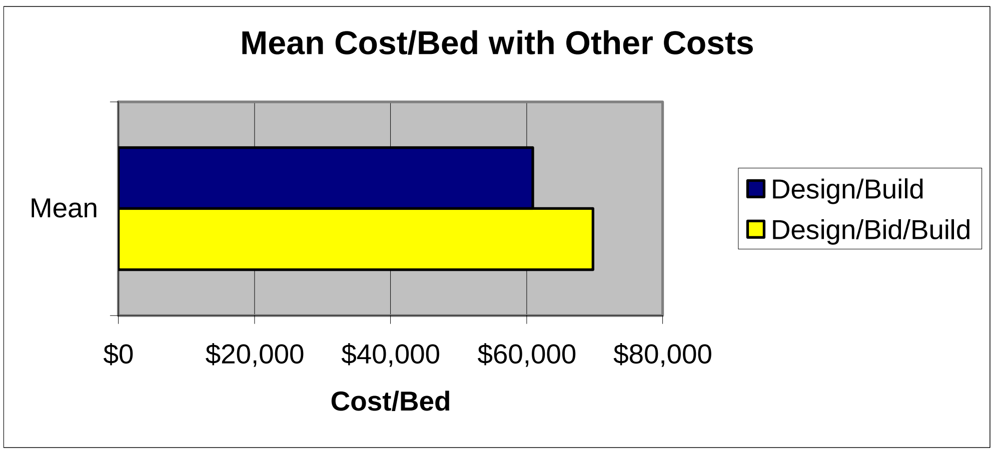

Figure 49: Mean Cost/Bed with Other Costs

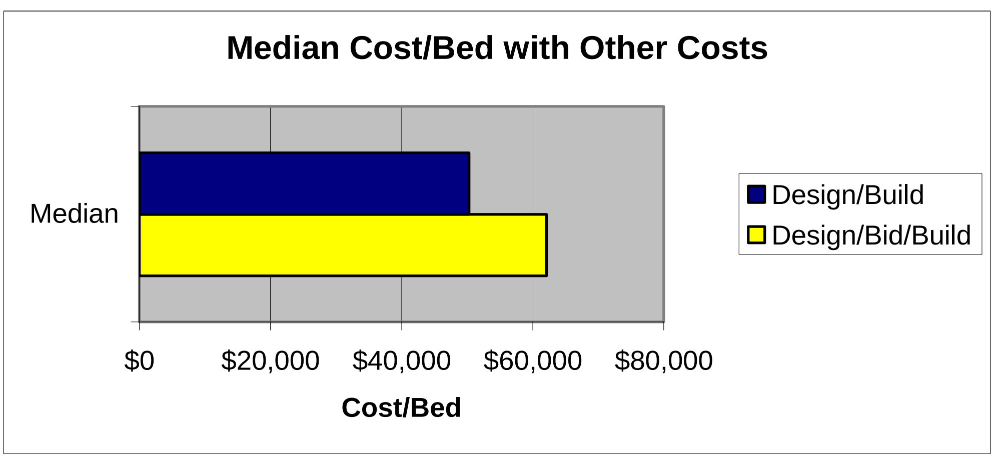

Figure 50: Median Cost/Bed with Other Costs

Table 19: Statistics for Cost/bed with Other Costs

	Design/Build	Design/Bid/Build
Number of Projects	38	39
Mean ($/bed)	$60,909	$69,760
Median ($/bed)	$50,302	$62,152
Standard Deviation ($/bed)	$29,020	$32,605

An analysis of variance (ANOVA) was conducted to determine if the means of the two samples were the same. The null hypothesis was that $\mu_{DB} = \mu_{DBB}$ where μ_{DB} = the mean Cost/Bed with Other Costs for the DB sample and μ_{DBB} = the mean Cost/Bed with Other Costs for the DBB sample. Table 20 shows the results.

Table 20: Single Factor ANOVA for Cost/bed with Other Costs

Groups	*Count*	*Sum*	*Average*	*Variance*
Design/Build	38	2314544	60909.06	8.42E+08
Design/Bid/Build	39	2720651	69760.29	1.06E+09

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.51E+09	1	1.51E+09	1.580402	0.212604	3.968471
Within Groups	7.16E+10	75	9.54E+08			
Total	7.31E+10	76				

The p-value is larger than 0.05 which is typically the standard for determining statistical significance. We can reject the null hypothesis with only a 79% certainty. We cannot statistically conclude that the samples' means are not the same, but evidence tends to indicate that the Cost/Bed with Other Costs for DB projects is lower than for DBB projects.

5.5 Cost per bed

As discussed above, numerous "other costs" may have had an impact on the cost/bed since each project has varying values of "other costs." Project costs were reduced based on the process described above to obtain the Cost/Bed.

Figure 51 and

Figure 52 show the cost/bed for DB and DBB. The distributions look somewhat similar. Most values are between $40,000 and $120,000. The peak of the distribution for DB is for projects with values between $60,000 and $80,000. The peak of the distribution for the DBB projects is in the $80,000 to $100,000 range The distributions for the DB versus the DBB projects for the cost/bed (

Figure 51 and

Figure 52) look more similar than the distributions for the DB versus the DBB projects for the cost/bed with other costs (

Figure 47 and

Figure 48).

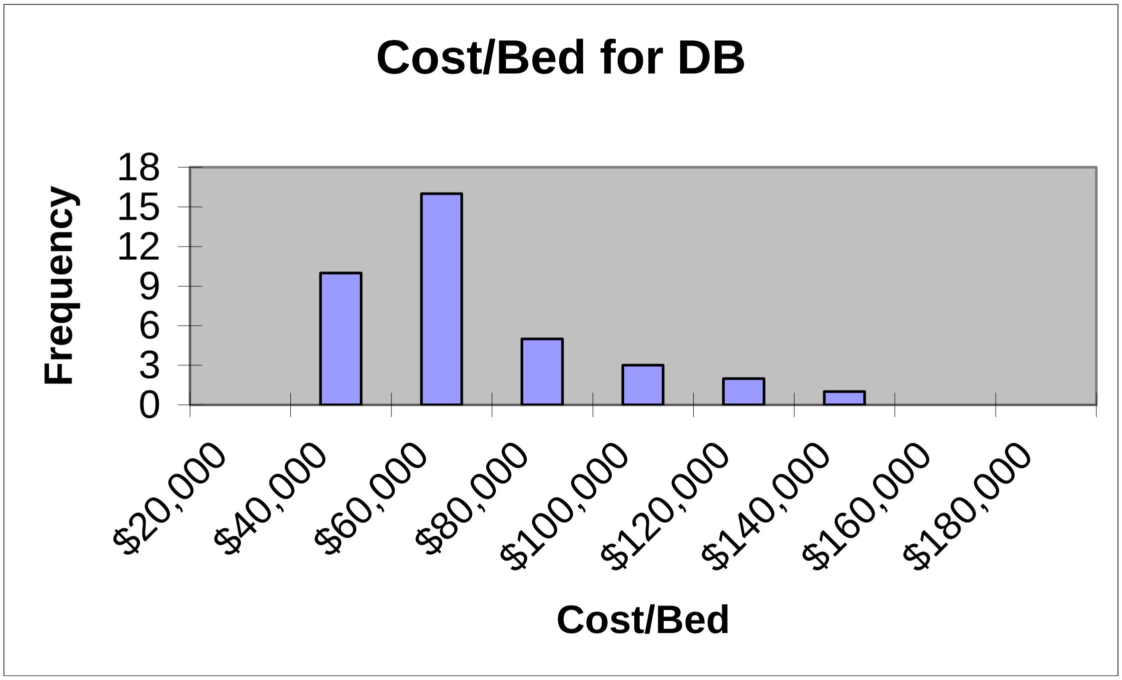

Figure 51: Cost/Bed for DB (N=38)

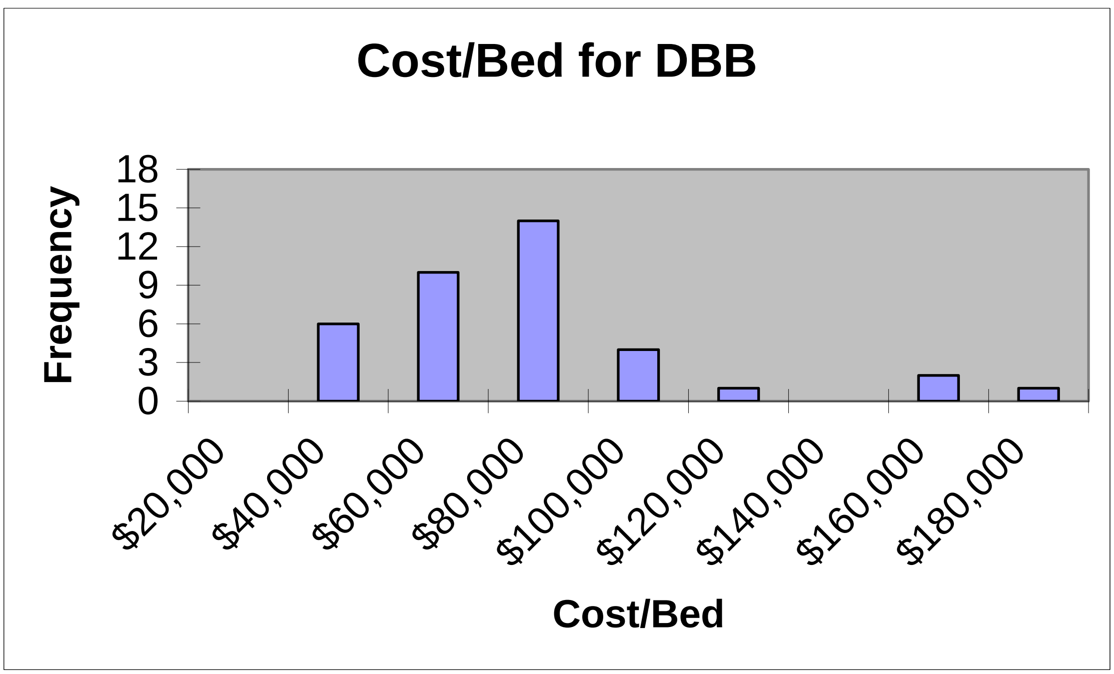

Figure 52: Cost/Bed for DBB (N=39)

Figure 53,

Figure 54 and Table 21 show the median, mean and standard deviation for the cost/bed metric. The difference between the mean ($10,000) and the median ($13,000) are similar to the cost/bed with Other Costs statistics (Figure 49 and

Figure 50 and Table 19). The means for both DB and DBB were about $10,000 lower for this cost/bed metric. The median for both the Cost/Bed and Cost/Bed with Other Costs were about the same indicating that the average values for Cost/Bed has a larger percent difference than the Cost/Bed with Other Costs. The median values however remained about the same. The Cost/Bed standard deviation for DB was reduced by about 15% but for DBB decreased only slightly (Table 19 and Table 21).

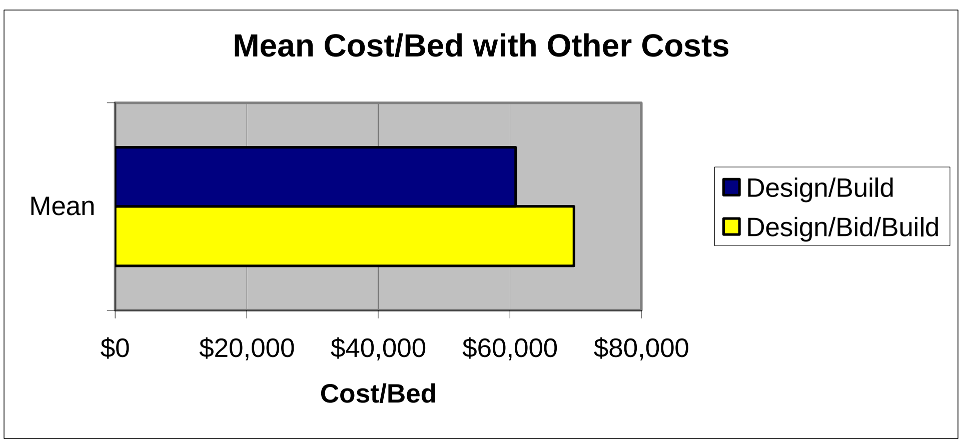

Figure 53: Mean Cost/Bed

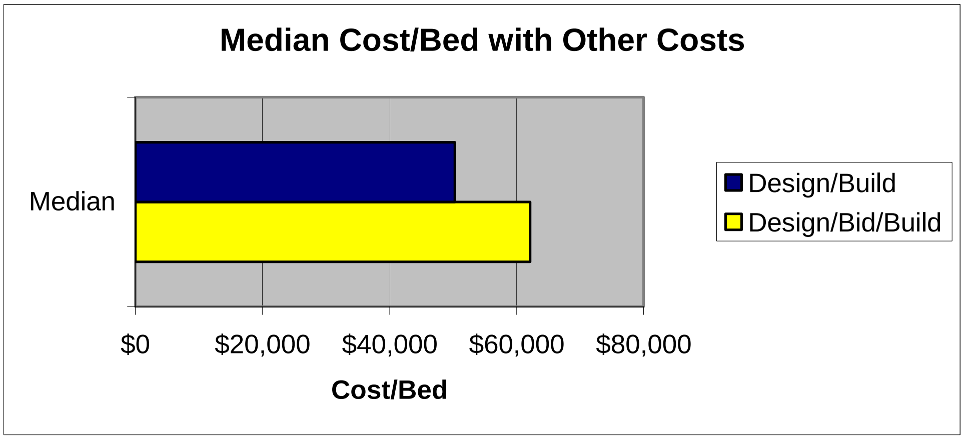

Figure 54: Median Cost/Bed

Table 21: Statistics for Cost/Bed

	Design/Build	Design/Bid/Build
Number of Projects	38	39
Mean ($/bed)	$57,776	$67,631
Median ($/bed)	$49,316	$62,152
Standard Deviation ($/bed)	$25,277	$31,266

A two-tail analysis of variance (ANOVA) was conducted to determine if the means of the two samples were the same. The null hypothesis was that $\mu_{DB} = \mu_{DBB}$ where μ_{DB} = the mean Cost/Bed for the DB sample and μ_{DBB} = the mean Cost/Bed for the DBB sample. Table 22 shows the results.

Table 22: Single Factor ANOVA for Cost/Bed

Groups	*Count*	*Sum*	*Average*	*Variance*
Design/Build	38	2195493	57776.12	6.39E+08
Design/Bid/Build	39	2637599	67630.74	9.78E+08

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.87E+09	1	1.87E+09	2.306095	0.133072	3.968471
Within Groups	6.08E+10	75	8.11E+08			
Total	6.27E+10	76				

The p-value is larger than .05 which is typically the standard for determining statistical significance. When the Other Costs are removed the p-value did decrease which gives us a stronger statistical reason to reject the null hypothesis. But the null hypothesis can be rejected with a 87% certainty. We cannot statistically conclude that the samples' means are not the same, but the evidence with the Other Costs removed more strongly indicates that the Cost/bed for DB projects is lower than for DBB projects.

5.6 Cost Growth

Another important metric is project cost growth. Inevitably a construction contract will have change orders. Minimizing the impacts of these changes on the overall cost of the project is important. The percentage of change in total contract cost was evaluated.

Figure 55 and Figure 56 show histograms for cost growth for the two samples. Figure 55 shows that the DB distribution is narrower than the DBB distribution of Figure 56. The DB projects are clustered between zero and five percent with no projects having a cost growth of greater than 10%. Conversely, the DBB distribution shows a wider distribution between negative two percent and nine percent cost growth. Four projects had cost growth greater than ten percent, with a maximum of 20 percent

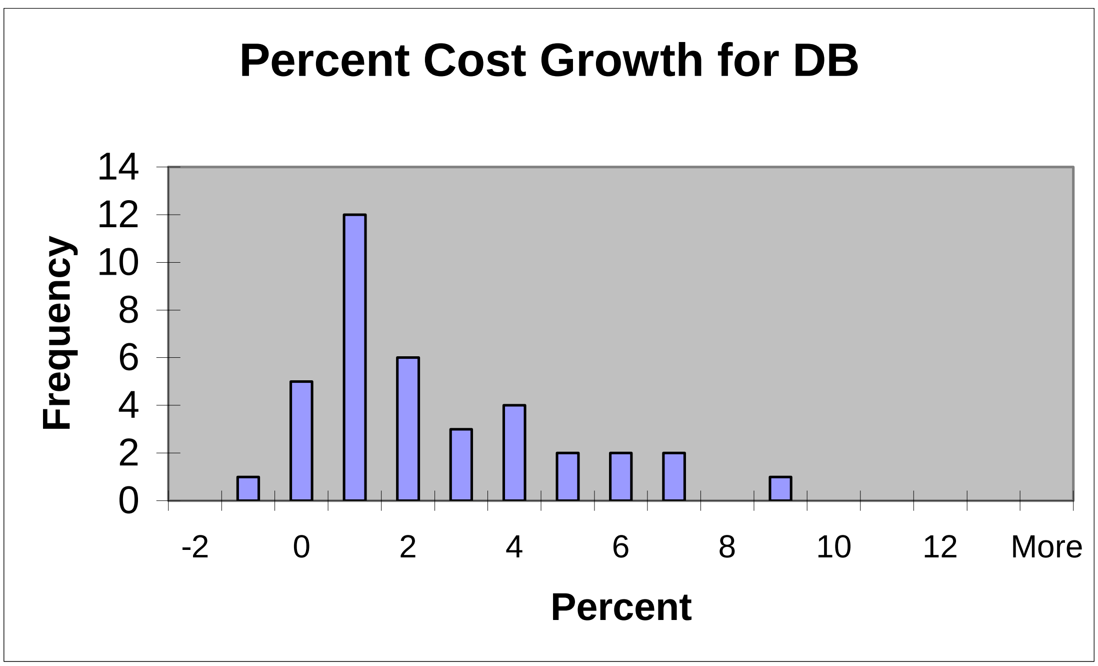

Figure 55: Cost Growth for DB (N=38)

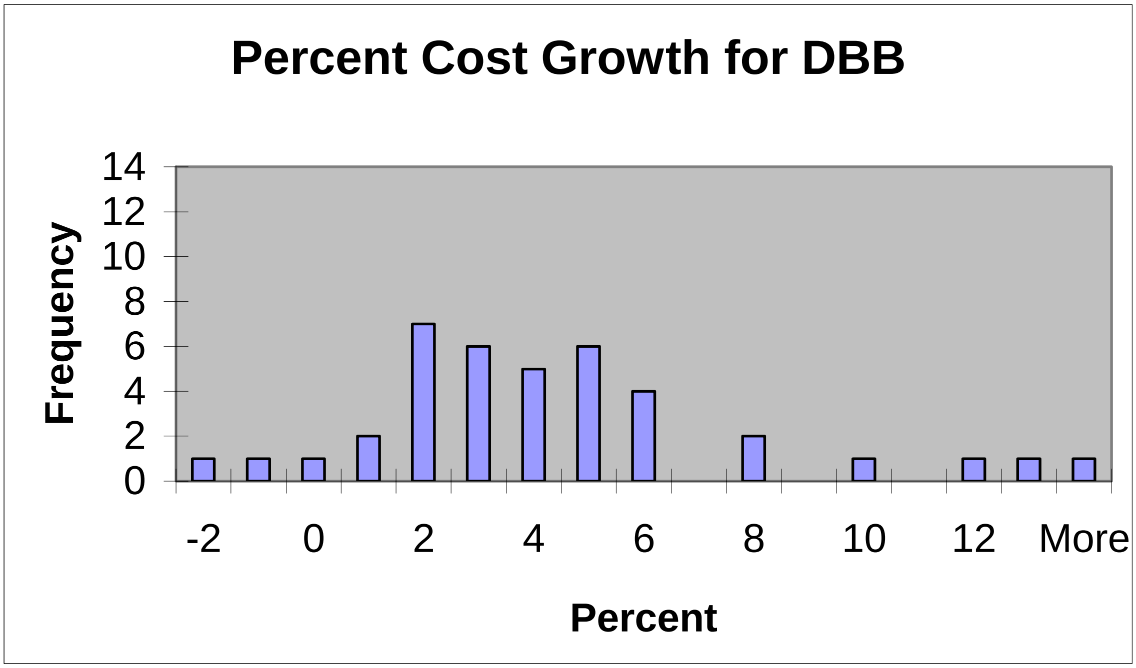

Figure 56: Cost Growth for DBB (N=39)

Figure 57, Figure 58 and Table 23 show that the mean cost growth for DB is about one-half the cost growth for DBB. The DB median cost growth is less than about one-third the median cost growth for DBB. The DB standard deviation is almost one-half the DBB standard deviation. Based on these statistics the two samples appear to have different distributions.

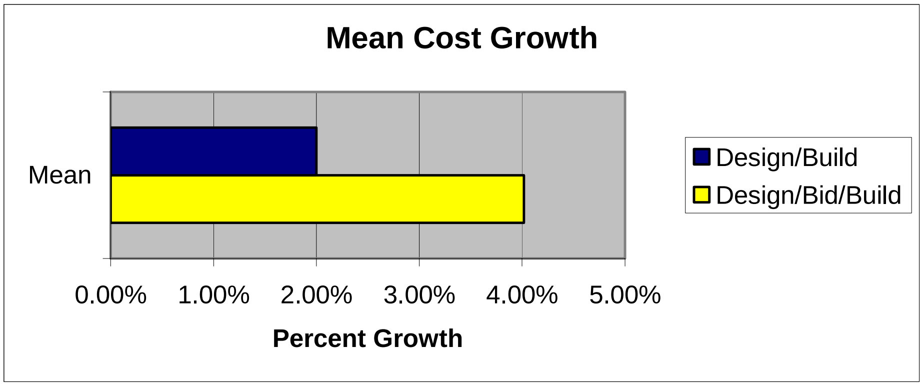

Figure 57: Mean Cost Growth

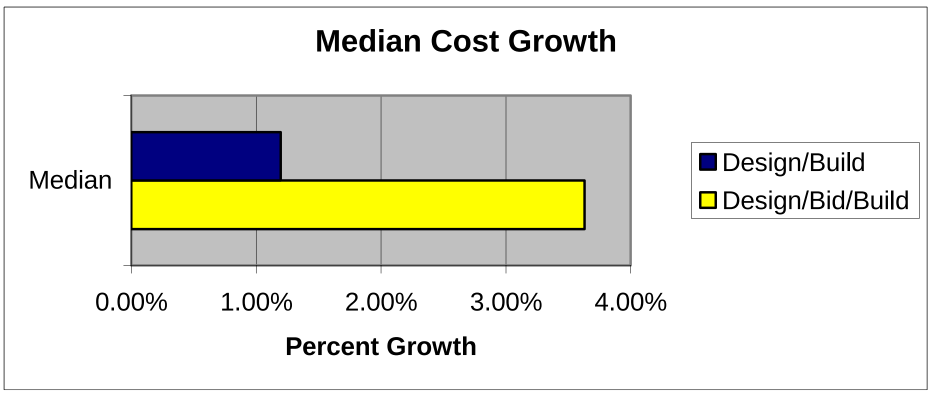

Figure 58: Median Cost Growth

Table 23: Statistics for Cost Growth

	Design/Build	Design/Bid/Build
Number of Projects	38	39
Mean	2.00%	4.02%
Median	1.20%	3.63%
Standard Deviation	2.21%	4.26%

An analysis of variance (ANOVA) was conducted to determine if the means of the two samples were the same. The null hypothesis was that $\mu_{DB} = \mu_{DBB}$ where μ_{DB}

= the mean cost growth for the DB sample and μ_{DBB} = the mean cost growth for the DBB sample. Table 24 shows the results.

Table 24: Single Factor ANOVA for Cost Growth

Groups	*Count*	*Sum*	*Average*	*Variance*
Design/Build	38	0.759764	0.019994	0.00049
Design/Bid/Build	39	1.566398	0.040164	0.001817

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.00783	1	0.00783	6.737803	0.011351	3.968471
Within Groups	0.087161	75	0.001162			
Total	0.094992	76				

Since the p-value is about 0.01 we can reject the null hypothesis with statistical certainty confirming the difference in sample means. We can conclude that the cost growth for a DB project is lower than the cost growth for a DBB project in this sample.

One possible explanation for the differences in cost growth could be attributed to the different EFD/EFA's that managed the projects, so Figure 59 was developed to compare the average cost growth at each EFD/EFA. As mentioned in the previous section, EFA Northwest and EFD Pacific did not have any DB projects. One unusual spike in the data is for the average DBB cost growth for EFA Northwest. This average is actually only one project, so this spike can be attributed to a small sample size. EFD Atlantic had a wide disparity for cost growth between DB and DBB. The averages for

DB and DBB were developed from 4 and 12 projects respectively, so the data are not skewed by a small sample size. EFA Chesapeake is the only EFD/EFA that has a higher average cost growth for DB projects than DBB projects. The difference in cost growth is almost one percent (5.71% to 4.93%). One contributing factor could be the sample size. The DB sample is three projects and the DBB sample is only one project. The DBB cost growth is roughly in line with the cost growth in other EFD/EFA's. The DB cost growth is unusually high though. Possible reasons for this include inexperience in the management of the DB process, poor contractor performance, or poorly written DB RFP's. The DBB projects in this EFD/EFA seem to have more cost growth than other regions, but the DB projects' cost growth seems to be comparable to the other EFD/EFA's. The other EFD/EFA's seemed to have reasonably comparable data between DB and DBB and it doesn't appear that time growth is affected by the EFA/EFD personnel.

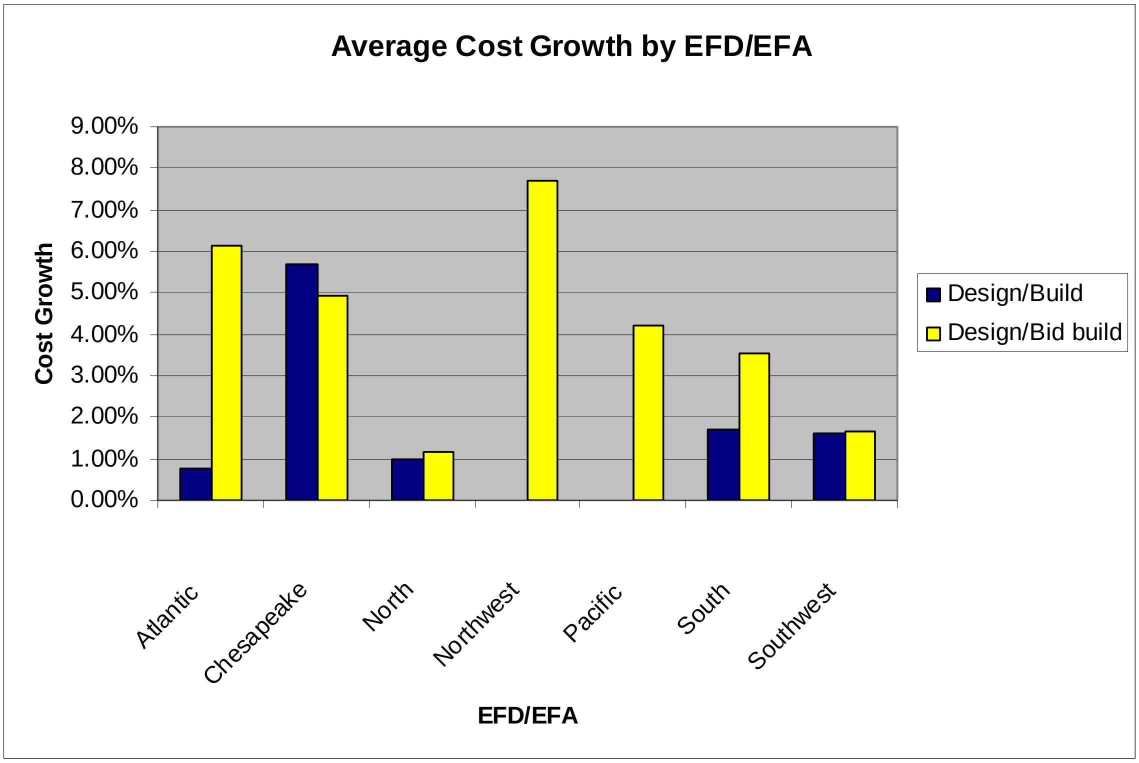

Figure 59: Average Cost Growth by EFD/EFA

5.7 Summary

Several comparisons of project duration, project duration per bed, project time growth, cost per bed and cost growth were conducted on the sample using statistical analysis as shown in

Table 25. All time comparisons showed a statistically significant difference between DBB and DB. Most notably the project time and days per bed comparisons of project start duration for DB and construction start duration for DBB were significantly different. Time growth was found to be less for DB projects. The difference between the two sub-samples for the cost per bed was not as convincing as the time comparisons. Only the cost per bed without Other Costs showed a statistical significance and that value was not lower than 0.05. Cost growth was conclusively shown to be less for DB projects than

DBB projects. So DB projects in this sample are faster and have less time and cost growth.

Table 25: Summary of Findings

Statistics	Design/Build	Design/Bid/Build
Project Duration -Total Project Duration -Fiscal Year Duration -Project/Construction Start Duration	667 days* 864 days* 667 days*	1398 days 1026 days 771 days
Project Duration per Bed -Total Project Duration -Fiscal Year Duration -Project/Construction Start Duration	2.64 days/bed* 3.55 days/bed* 2.64 days/bed*	7.00 days/bed 5.08 days/bed 3.70 days/bed
Time Growth	76.39 days*	193.85 days
Cost per Bed with Other Costs	$60,909	$69,760
Cost per Bed	$57,776	$67,152
Cost Growth	2.00%*	4.02%

* Statistically significant at $p < 0.05$

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This thesis has collected data and analyzed two relatively homogeneous samples of DB and DBB projects. All of the projects consisted of new BEQ's that had prescribed dimensions for each living quarters. All projects were administered by the same organization (NAVFAC) with an adequate geographical dispersion throughout the United States. Both samples were similar in size and large enough (37 DB projects and 38 DBB) to conduct ANOVA tests. Because this sample is unique to NAVFAC, care should be taken when extending the results of this study to other types of projects and organizations.

The analysis has shown that the differences in the analyzed cost and time metrics are statistically significant. Below are the specific conclusions based on the analysis.

6.1.1 Project Duration

- Within the selected sample of NAVFAC MILCON BEQ projects, the DB project delivery method showed substantial time savings. The Total Project Duration was calculated as the difference between the date of the first contract award (design award for DB and project award for DBB) and the actual project completion. The statistical comparisons of sample means showed that the Total Project Duration was shorter for DB project at a statistically significant level. The average difference was 734 days (24 months) per project.

- Within the selected sample of NAVFAC MILCON BEQ projects, the DB project delivery method showed substantial time savings when the start date for the project was linked to the first day of the fiscal year. This comparison was conducted since the Congressional budgetary process may influence DBB durations since DBB's designs must wait for project approval by Congress before the projects may be solicited for bids. Fiscal Year Duration was calculated as the difference between the contract completion date and the beginning of the FY authorized. The statistical comparisons of sample means showed that the FY Duration was shorter for DB projects at a statistically significant level. The average difference was 165 days (5.5 months) per project.
- Within the selected sample of NAVFAC MILCON BEQ projects, the DB project delivery method showed time savings when the start date for the project was linked to the first contract action after the beginning of the fiscal year. The Project/Construction Start Duration included both the time for design and construction for the DB sample and included only the time for construction for the DBB sample. The statistical comparisons of sample means showed that the FY Duration was shorter for DB project at a statistically significant level. The average difference was 106 days (3.5 months) per project.

6.1.2 Project Duration per Bed

Since the projects constructed various quantities of beds, comparisons of the days/bed were conducted using the aforementioned durations.

- Within the selected sample of NAVFAC MILCON BEQ projects, the DB project delivery method showed substantial time savings per bed. The statistical comparisons of sample means showed that the days/bed using the Total Project Duration was shorter for DB project at a statistically significant level. The average difference was 4.37 days/bed.
- Within the selected sample of NAVFAC MILCON BEQ projects, the DB project delivery method showed substantial time savings per bed when the start date for the project was linked to the first day of the fiscal year. The statistical comparisons of sample means showed that the days/bed using FY Duration was shorter for DB project at a statistically significant level. The average difference was 1.54 days/bed.
- Within the selected sample of NAVFAC MILCON BEQ projects, the DB project delivery method showed time savings when the start date for the project was linked to the first contract action after the beginning of the fiscal year. The Project/Construction Start Duration included both the time for design and construction for the DB sample and included only the time for construction for the DBB sample. The statistical comparisons of sample means showed that the FY Duration was shorter for DB project at a statistically significant level. The average difference was 1.07 days/bed.

6.1.3 Time Growth

- Within the selected sample of NAVFAC MILCON BEQ projects, the DB project delivery method proved to have less time growth in days. The statistical comparisons of sample means showed that Time Growth was smaller for DB project at a statistical significant level. The average difference was 120 days (4 months).

6.1.4 Cost/bed with Other Costs

. Two comparisons of cost/bed were conducted. The first metric compared the Cost/Bed with Other Costs included, which represented the entire cost of the facility.

- When the projects were developed, many times scope was included that did not relate to the barracks or was a demolition cost. These costs were termed Other Costs. These Other Costs included construction of non-BEQ facilities, demolition, and environmental mitigation. Within the selected sample of NAVFAC MILCON BEQ projects, the DB project delivery method appears to cost less per bed, but the results were not statistically significant. The null hypothesis that the sample means of Cost/bed with Other Costs could not be rejected. However, the average difference was $8851/bed.

6.1.5 Cost/Bed with Other Costs Removed

- Within the selected sample of NAVFAC MILCON BEQ projects with other costs removed, the DB project delivery method appears to cost less per bed, but the results were not statistically significant. The statistical comparisons of sample means showed that Cost was smaller for DB project.

6.1.6 Cost Growth

- Within the selected sample of NAVFAC MILCON BEQ projects, the DB project delivery method proved to have less cost growth in days. The statistical comparisons of sample means showed that Cost Growth was smaller for DB project at a statistically significant level. The average difference was 2.02%.

6.1.7 Summary

The results show that DB is a superior project delivery method when constructing U.S. Navy BEQ's. Several time comparisons showed that the projects will be completed faster with this method. Since time growth for DB projects was significantly less than DBB projects, DB BEQ's projects should have more predictable completion dates. Cost growth for DB projects was also shown to be less. Although not statistically significant, the DB BEQ's should also be less expensive to build.

6.2 Recommendations

Based on the data analyzed in this thesis the below recommendations are made:

- NAVFAC should continue to utilize DB for all BEQ projects within the United States. The data indicates that BEQ DB projects will take less time to complete and have less time and cost growth. The data also seems to indicate that the DB projects will cost less per bed.
- Since both samples were similar in size and facility type, the conclusion could be made that the benefits of DB transcends just BEQ projects. Therefore NAVFAC

should use DB in all projects feasible to take advantage of the cost and time benefits.

- Since NAVFAC is a public sector organization and many public sector organizations operate in similar fashion, the conclusion could be made that the benefits of DB will transcend just NAVFAC projects. Therefore the public sector should strongly consider DB to take advantage of cost and time benefits.
- The data was so convincing that for the cost and time benefits, the differences between the public and private sector construction could be marginalized. The private sector should also strongly consider DB to take advantage of the cost and time benefits.
- DD Form 1391 should have separate line items for demolition and site improvement and paving to more easily accommodate similar studies to this thesis.
- eProjects should link to the DD Form 1391's for the project.
- NAVFAC should continue to develop eProjects and keep the databases populated. With continued use of eProjects the data should be available to more easily collect data for similar studies.

6.3 Further Study

This study could be expanded to detect additional benefits of DB or DBB project delivery. It did not take into account quality of the final product. The benefits of DB could have been at the expense of quality. An additional study could also be completed to see if the likelihood of claims is linked to project delivery method.

APPENDICES

Appendix A: Raw Data

Refer.	FY	LOCATION	Total Beds	Start Date			Original Project Completion	Actual Project Completion	Original Project Duration		
				Total Project Duration	FY Duration	Const/Proj Start Duration			Total Project Duration (Days)	FY Duration (Days)	Const/Proj Start Duration (Days)
DB-1	1996	ANNAPOLIS MD NAVACAD	40	6/14/1996	10/1/1995	6/14/1996	9/27/1997	9/27/1997	470	727	470
DB-2	1997	GREAT LAKES IL NH	410	9/12/1997	10/1/1996	9/12/1997	3/21/1999	8/11/1999	555	901	555
DB-3	1997	GREAT LAKES IL NSTC	660	9/12/1997	10/1/1996	9/12/1997	3/21/1999	8/11/1999	555	901	555
DB-4	1997	SAN DIEGO CA NAS NORTH IS	150	9/10/1997	10/1/1996	9/10/1997	11/19/1998	10/29/1999	435	779	435
DB-5	1997	WASHINGTON DC COMNAVDIST	250	10/25/1996	10/1/1996	10/25/1996	4/28/1998	4/28/1998	550	574	550
DB-6	1998	BEAUFORT SC MCAS	422	9/29/1998	10/1/1997	9/29/1998	6/19/2000	2/6/2001	629	992	629
DB-7	1998	CAMP PENDLETON CA MCB	320	3/31/1998	10/1/1997	3/31/1998	6/15/1999	6/15/1999	441	622	441
DB-8	1998	CAMP PENDLETON CA MCB	400	7/17/1998	10/1/1997	7/17/1998	11/22/1999	11/22/1999	493	782	493
DB-9	1998	GREAT LAKES IL NSTC	820	9/12/1997	10/1/1997	9/12/1997	3/21/1999	8/11/1999	555	536	555
DB-10	1998	YUMA AZ MCAS	350	7/30/1998	10/1/1997	7/30/1998	2/1/2001	1/10/2001	917	1219	917
DB-11	1999	CAMP PENDLETON CA MCB	320	2/18/1999	10/1/1998	2/18/1999	6/25/2000	9/14/2000	493	633	493
DB-12	1999	CAMP PENDLETON CA MCB	400	12/15/1998	10/1/1998	12/15/1998	5/5/2000	5/5/2001	507	582	507
DB-13	1999	GULFPORT MS NCBC	214	12/16/1998	10/1/1998	12/16/1998	3/15/2000	6/2/2000	455	531	455
DB-14	1999	INGLESIDE TX NS	200	6/24/1999	10/1/1998	6/24/1999	10/12/2000	1/8/2001	476	742	476
DB-15	1999	SAN DIEGO CA NAS NORTH IS	90	5/25/1999	10/1/1998	5/25/1999	8/15/2000	9/20/2000	448	684	448
DB-16	1999	YUMA AZ MCAS	316	7/30/1998	10/1/1998	7/30/1998	2/1/2001	1/10/2001	917	854	917
DB-17	2000	CAMP PENDLETON CA MCB	200	3/30/2000	10/1/1999	3/30/2000	11/7/2001	2/6/2002	587	768	587
DB-18	2000	QUANTICO VA MCCOMBDEV CMD	600	1/20/2000	10/1/1999	1/20/2000	6/18/2001	5/8/2002	515	626	515
DB-19	2000	TWENTYNINE PALMS CA	124	10/29/1999	10/1/1999	10/29/1999	3/21/2001	2/20/2001	509	537	509
DB-20	2000	TWENTYNINE PALMS CA MAGCC	384	12/22/1999	10/1/1999	12/22/1999	1/5/2001	1/29/2001	380	462	380
DB-21	2001	CAMP LEJEUNE NC MCB	400	2/28/2001	10/1/2000	2/28/2001	1/4/2003	2/11/2003	675	825	675
DB-22	2001	TWENTYNINE PALMS CA MAGCC	384	5/31/2001	10/1/2000	5/31/2001	6/10/2002	7/29/2002	375	617	375
DB-23	2001	WASH DC MARBARRACKS	332	9/14/2001	10/1/2000	9/14/2001	9/15/2003	8/27/2004	731	1079	731
DB-24	2002	BRUNSWICK ME NAS	250	9/18/2002	10/1/2001	9/18/2002	9/22/2004	7/13/2004	735	1087	735
DB-26	2002	CAMP LEJEUNE NC MCB	400	2/1/2002	10/1/2001	2/1/2002	5/6/2004	7/21/2004	825	948	825
DB-25	2002	CAMP LEJEUNE NC MCB	320	2/1/2002	10/1/2001	2/1/2002	5/6/2004	7/21/2004	825	948	825

				Start Date					Original Project Duration		
Refer.	FY	LOCATION	Total Beds	Total Project Duration	FY Duration	Const/Proj Start Duration	Original Project Completion	Actual Project Completion	Total Project Duration (Days)	FY Duration (Days)	Const/Proj Start Duration (Days)
DB-28	2002	CAMP PENDLETON CA MCB	400	3/29/2002	10/1/2001	3/29/2002	2/3/2004	5/17/2004	676	855	676
DB-27	2002	CAMP PENDLETON CA MCB	400	6/18/2002	10/1/2001	6/18/2002	7/14/2004	5/27/2004	757	1017	757
DB-29	2002	EL CENTRO CA NAF	160	3/27/2002	10/1/2001	3/27/2002	5/9/2003	5/9/2003	408	585	408
DB-30	2002	GULFPORT MS NAVCONSTRACEN	180	4/18/2002	10/1/2001	4/18/2002	11/20/2003	10/17/2003	581	780	581
DB-31	2002	KANSAS CITY MO	196	1/31/2003	10/1/2001	1/31/2003	6/15/2004	6/15/2004	501	988	501
DB-32	2002	MAYPORT FL NS	260	8/13/2002	10/1/2001	8/13/2002	8/13/2004	8/13/2004	731	1047	731
DB-33	2002	SAN DIEGO CA NAVSTA	516	7/30/2002	10/1/2001	7/30/2002	10/2/2004	10/2/2004	795	1097	795
DB-34	2002	TWENTYNINE PALMS CA MAGCC	384	4/30/2002	10/1/2001	4/30/2002	7/14/2003	1/4/2004	440	651	440
DB-35	2003	CAMP PENDLETON CA MCB	400	12/27/2002	10/1/2002	12/27/2002	4/29/2005	6/15/2005	854	941	854
DB-36	2003	PASCAGOULA MS NS	100	4/30/2003	10/1/2002	4/30/2003	1/28/2005	1/28/2005	639	850	639
DB-37	2003	TWENTYNINE PALMS CA MAGCC	384	12/27/2002	10/1/2002	12/27/2002	8/27/2004	8/27/2004	609	696	609
DB-38	2004	TWENTYNINE PALMS CA MAGCC	384	12/22/2003	10/1/2003	12/22/2003	1/20/2005	5/25/2005	395	477	395

				Start Date					Original Project Duration		
Reference	FY	LOCATION	Total Beds	Total Project Duration	FY Duration	Const/Proj Start Duration	Original Project Completion	Actual Project Completion	Total Project Duration (Days)	FY Duration (Days)	Const/Proj Start Duration (Days)
DBB-1	1995	EVERETT WA NAVSTA	232	2/20/1991	10/1/1994	2/9/1995	5/24/1996	5/24/1996	1920	601	470
DBB-2	1995	NORFOLK VA NS	720	11/4/1993	10/1/1994	4/21/1995	3/26/1997	11/27/1997	1238	907	705
DBB-3	1996	BEAUFORT SC MCAS	476	2/7/1996	10/1/1995	2/19/1997	10/27/1998	8/30/1999	993	1122	615
DBB-4	1996	CAMP PENDLETON CA MCB	400	9/30/1994	10/1/1995	9/11/1996	7/22/1997	9/14/1998	1026	660	314
DBB-5	1996	CORPUS CHRISTI TX NAS	96	12/8/1995	10/1/1995	9/26/1996	10/11/1997	1/12/1998	673	741	380
DBB-6	1996	NEW RIVER NC MCAS	322	4/12/1995	10/1/1995	9/26/1996	7/3/1998	9/17/1998	1178	1006	645
DBB-7	1996	PORT HUENEME CA NFELC	329	1/28/1992	10/1/1995	9/26/1996	2/3/1998	5/30/2000	2198	856	495
DBB-8	1996	PORTSMOUTH VA NH	278	4/17/1995	10/1/1995	6/6/1996	3/13/1998	12/19/1998	1061	894	645
DBB-9	1996	SUGAR GROVE WV NSGD	106	12/12/1995	10/1/1995	9/26/1996	12/4/1998	12/4/1998	1088	1160	799
DBB-10	1996	WILLIAMSBURG VA FISC CA	122	5/3/1994	10/1/1995	4/10/1996	9/7/1997	1/14/1998	1223	707	515
DBB-11	1997	CAMP LEJEUNE NC MCB	200	4/18/1995	10/1/1996	9/30/1997	2/27/1999	8/31/1999	1411	879	515
DBB-12	1997	CAMP PENDLETON CA MCB	320	4/24/1997	10/1/1996	8/11/1997	8/26/1998	2/8/1999	489	694	380
DBB-13	1997	CAMP PENDLETON CA MCB	360	8/29/1996	10/1/1996	2/27/1997	5/11/1998	9/19/1998	620	587	438
DBB-14	1997	CRANE IN NAVSURFWARCEN	72	9/13/1996	10/1/1996	2/11/1998	4/7/1999	6/18/1999	936	918	420
DBB-15	1997	DAHLGREN VA NSWCTR DIV	164	3/3/1995	10/1/1996	12/22/1998	2/7/2001	7/12/2001	2168	1590	778
DBB-16	1997	EVERETT WA NAVSTA	202	8/1/1996	10/1/1996	6/30/1997	3/17/1999	12/17/1999	958	897	625
DBB-17	1997	FALLON NV NAS	100	1/29/1997	10/1/1996	9/30/1997	6/27/1998	2/19/2000	514	634	270
DBB-18	1997	INGLESIDE TX NS	186	4/5/1996	10/1/1996	6/30/1997	11/12/1998	4/27/1999	951	772	500
DBB-19	1997	KANEOHE BAY HI MCB	300	9/30/1996	10/1/1996	9/22/1997	3/26/1999	4/27/2000	907	906	550
DBB-20	1997	NEW LONDON CT NSB	200	4/22/1996	10/1/1996	9/30/1997	11/24/1998	2/16/1999	946	784	420
DBB-21	1997	PEARL HARBOR HI NSB	358	3/5/1996	10/1/1996	5/2/1997	1/22/1999	4/27/1999	1053	843	630
DBB-22	1998	KANEOHE BAY HI MCB	360	4/18/1997	10/1/1997	9/22/1997	3/26/1999	4/27/2000	707	541	550

				Start Date					Original Project Duration		
Reference	FY	LOCATION	Total Beds	Total Project Duration	FY Duration	Const/Proj Start Duration	Original Project Completion	Actual Project Completion	Total Project Duration (Days)	FY Duration (Days)	Const/Proj Start Duration (Days)
DBB-23	1998	NEW RIVER NC MCAS	320	1/28/1997	10/1/1997	9/15/1998	11/9/2000	7/18/2001	1381	1135	786
DBB-24	1998	OCEANA VA NAS	460	4/17/1998	10/1/1997	5/19/1998	5/23/2000	8/30/2000	767	965	735
DBB-25	1999	KANEOHE BAY HI MCB	408	12/12/1997	10/1/1998	12/22/1998	7/14/2000	9/18/2000	945	652	570
DBB-26	1999	KANEOHE BAY HI MCB	300	9/17/1998	10/1/1998	6/30/1999	1/20/2001	3/2/2001	856	842	570
DBB-27	1999	MIRAMAR CA MCAS	744	5/6/1994	10/1/1998	12/18/1998	7/12/2000	9/6/2000	2259	650	572
DBB-28	2000	BRUNSWICK ME NAS	380	5/27/1999	10/1/1999	3/24/2000	8/14/2002	9/28/2002	1175	1048	873
DBB-29	2000	DAM NECK VA	180	5/4/1998	10/1/1999	12/20/1999	4/10/2001	10/6/2001	1072	557	477
DBB-30	2000	PORTSMOUTH VA NORF NSY	119	5/4/1999	10/1/1999	5/22/2000	5/27/2002	3/16/2004	1119	969	735
DBB-31	2001	KANEOHE BAY HI MCB	300	8/26/1999	10/1/2000	1/31/2001	8/24/2002	9/16/2002	1094	692	570
DBB-32	2001	LEMOORE CA NAS	152	12/15/1994	10/1/2000	12/15/2000	2/24/2002	5/15/2002	2628	511	436
DBB-33	2001	PEARL HARBOR HI NS	236	9/28/1999	10/1/2000	5/22/2001	3/17/2003	6/8/2003	1266	897	664
DBB-34	2001	PORTSMOUTH VA NORF NSY	378	11/5/1999	10/1/2000	5/22/2000	5/27/2002	12/11/2002	934	603	735
DBB-35	2002	KANEOHE BAY HI MCB	300	11/9/2001	10/1/2001	9/27/2002	6/18/2004	11/30/2004	952	991	630
DBB-36	2002	KITTERY ME PORTS NSY	178	2/5/2001	10/1/2001	4/26/2002	9/27/2003	5/3/2004	964	726	519
DBB-37	2002	LEMOORE CA NAS	104	12/15/1994	10/1/2001	2/1/2002	8/10/2003	8/10/2003	3160	678	555
DBB-38	2002	PEARL HARBOR HI NS	112	8/20/2001	10/1/2001	6/13/2002	4/13/2004	1/26/2005	967	925	670
DBB-39	2003	YORKTOWN VA NWS	168	1/14/2002	10/1/2002	3/28/2003	4/1/2005	3/15/2005	1173	913	735

Refer.	Total Project Duration			FY Duration			Const/Proj Start Duration			Time/Bed		
	Final Project Duration (Days)	Change in Project Duration (Days)	Percent Change in Project Duration	Final Project Duration (Days)	Change in Project Duration (Days)	Percent Change in Project Duration	Final Project Duration (Days)	Change in Project Duration (Days)	Percent Change in Project Duration	Total Project Duration (Days/Bed)	FY Duration (Days/ Bed)	Const/Proj Start Duration (Days/Bed)
DB-1	470	0	0.00%	727	0	0.00%	470	0	0.00%	11.75	18.18	11.75
DB-2	698	143	25.77%	1044	143	15.87%	698	143	25.77%	1.70	2.55	1.70
DB-3	698	143	25.77%	1044	143	15.87%	698	143	25.77%	1.06	1.58	1.06
DB-4	779	344	79.08%	1123	344	44.16%	779	344	79.08%	5.19	7.49	5.19
DB-5	550	0	0.00%	574	0	0.00%	550	0	0.00%	2.20	2.30	2.20
DB-6	861	232	36.88%	1224	232	23.39%	861	232	36.88%	2.04	2.90	2.04
DB-7	441	0	0.00%	622	0	0.00%	441	0	0.00%	1.38	1.94	1.38
DB-8	493	0	0.00%	782	0	0.00%	493	0	0.00%	1.23	1.96	1.23
DB-9	698	143	25.77%	679	143	26.68%	698	143	25.77%	0.85	0.83	0.85
DB-10	895	-22	-2.40%	1197	-22	-1.80%	895	-22	-2.40%	2.56	3.42	2.56
DB-11	574	81	16.43%	714	81	12.80%	574	81	16.43%	1.79	2.23	1.79
DB-12	872	365	71.99%	947	365	62.71%	872	365	71.99%	2.18	2.37	2.18
DB-13	534	79	17.36%	610	79	14.88%	534	79	17.36%	2.50	2.85	2.50
DB-14	564	88	18.49%	830	88	11.86%	564	88	18.49%	2.82	4.15	2.82
DB-15	484	36	8.04%	720	36	5.26%	484	36	8.04%	5.38	8.00	5.38
DB-16	895	-22	-2.40%	832	-22	-2.58%	895	-22	-2.40%	2.83	2.63	2.83
DB-17	678	91	15.50%	859	91	11.85%	678	91	15.50%	3.39	4.30	3.39
DB-18	839	324	62.91%	950	324	51.76%	839	324	62.91%	1.40	1.58	1.40
DB-19	480	-29	-5.70%	508	-29	-5.40%	480	-29	-5.70%	3.87	4.10	3.87
DB-20	404	24	6.32%	486	24	5.19%	404	24	6.32%	1.05	1.27	1.05
DB-21	713	38	5.63%	863	38	4.61%	713	38	5.63%	1.78	2.16	1.78
DB-22	424	49	13.07%	666	49	7.94%	424	49	13.07%	1.10	1.73	1.10

	Total Project Duration			FY Duration			Const/Proj Start Duration			Time/Bed		
Refer.	Final Project Duration (Days)	Change in Project Duration (Days)	Percent Change in Project Duration	Final Project Duration (Days)	Change in Project Duration (Days)	Percent Change in Project Duration	Final Project Duration (Days)	Change in Project Duration (Days)	Percent Change in Project Duration	Total Project Duration (Days/Bed)	FY Duration (Days/ Bed)	Const/Proj Start Duration (Days/Bed)
DB-23	1078	347	47.47%	1426	347	32.16%	1078	347	47.47%	3.25	4.30	3.25
DB-24	664	-71	-9.66%	1016	-71	-6.53%	664	-71	-9.66%	2.66	4.06	2.66
DB-26	901	76	9.21%	1024	76	8.02%	901	76	9.21%	2.25	2.56	2.25
DB-25	901	76	9.21%	1024	76	8.02%	901	76	9.21%	2.82	3.20	2.82
DB-28	780	104	15.38%	959	104	12.16%	780	104	15.38%	1.95	2.40	1.95
DB-27	709	-48	-6.34%	969	-48	-4.72%	709	-48	-6.34%	1.77	2.42	1.77
DB-29	408	0	0.00%	585	0	0.00%	408	0	0.00%	2.55	3.66	2.55
DB-30	547	-34	-5.85%	746	-34	-4.36%	547	-34	-5.85%	3.04	4.14	3.04
DB-31	501	0	0.00%	988	0	0.00%	501	0	0.00%	2.56	5.04	2.56
DB-32	731	0	0.00%	1047	0	0.00%	731	0	0.00%	2.81	4.03	2.81
DB-33	795	0	0.00%	1097	0	0.00%	795	0	0.00%	1.54	2.13	1.54
DB-34	614	174	39.55%	825	174	26.73%	614	174	39.55%	1.60	2.15	1.60
DB-35	901	47	5.50%	988	47	4.99%	901	47	5.50%	2.25	2.47	2.25
DB-36	639	0	0.00%	850	0	0.00%	639	0	0.00%	6.39	8.50	6.39
DB-37	609	0	0.00%	696	0	0.00%	609	0	0.00%	1.59	1.81	1.59
DB-38	520	125	31.65%	602	125	26.21%	520	125	31.65%	1.35	1.57	1.35

	Total Project Duration			FY Duration			Const/Proj Start Duration			Time/Bed		
Reference	Final Project Duration (Days)	Change in Project Duration (Days)	Percent Change in Project Duration	Final Project Duration (Days)	Change in Project Duration (Days)	Percent Change in Project Duration	Final Project Duration (Days)	Change in Project Duration (Days)	Percent Change in Project Duration	Total Project Duration (Days/Bed)	FY Duration (Days/Bed)	Const/Proj Start Duration (Days/Bed)
DBB-1	1920	0	0.00%	601	0	0.00%	470	0	0.00%	8.28	2.59	2.03
DBB-2	1484	246	19.87%	1153	246	27.12%	951	246	34.89%	2.06	1.60	1.32
DBB-3	1300	307	30.92%	1429	307	27.36%	922	307	49.92%	2.73	3.00	1.94
DBB-4	1445	419	40.84%	1079	419	63.48%	733	419	133.44%	3.61	2.70	1.83
DBB-5	766	93	13.82%	834	93	12.55%	473	93	24.47%	7.98	8.69	4.93
DBB-6	1254	76	6.45%	1082	76	7.55%	721	76	11.78%	3.89	3.36	2.24
DBB-7	3045	847	38.54%	1703	847	98.95%	1342	847	171.11%	9.26	5.18	4.08
DBB-8	1342	281	26.48%	1175	281	31.43%	926	281	43.57%	4.83	4.23	3.33
DBB-9	1088	0	0.00%	1160	0	0.00%	799	0	0.00%	10.26	10.94	7.54
DBB-10	1352	129	10.55%	836	129	18.25%	644	129	25.05%	11.08	6.85	5.28
DBB-11	1596	185	13.11%	1064	185	21.05%	700	185	35.92%	7.98	5.32	3.50
DBB-12	655	166	33.95%	860	166	23.92%	546	166	43.68%	2.05	2.69	1.71
DBB-13	751	131	21.13%	718	131	22.32%	569	131	29.91%	2.09	1.99	1.58
DBB-14	1008	72	7.69%	990	72	7.84%	492	72	17.14%	14.00	13.75	6.83
DBB-15	2323	155	7.15%	1745	155	9.75%	933	155	19.92%	14.16	10.64	5.69
DBB-16	1233	275	28.71%	1172	275	30.66%	900	275	44.00%	6.10	5.80	4.46
DBB-17	1116	602	117.12%	1236	602	94.95%	872	602	222.96%	11.16	12.36	8.72
DBB-18	1117	166	17.46%	938	166	21.50%	666	166	33.20%	6.01	5.04	3.58
DBB-19	1305	398	43.88%	1304	398	43.93%	948	398	72.36%	4.35	4.35	3.16
DBB-20	1030	84	8.88%	868	84	10.71%	504	84	20.00%	5.15	4.34	2.52
DBB-21	1148	95	9.02%	938	95	11.27%	725	95	15.08%	3.21	2.62	2.03
DBB-22	1105	398	56.29%	939	398	73.57%	948	398	72.36%	3.07	2.61	2.63

	Total Project Duration			FY Duration			Const/Proj Start Duration			Time/Bed		
Reference	Final Project Duration (Days)	Change in Project Duration (Days)	Percent Change in Project Duration	Final Project Duration (Days)	Change in Project Duration (Days)	Percent Change in Project Duration	Final Project Duration (Days)	Change in Project Duration (Days)	Percent Change in Project Duration	Total Project Duration (Days/Bed)	FY Duration (Days/Bed)	Const/Proj Start Duration (Days/Bed)
DBB-23	1632	251	18.18%	1386	251	22.11%	1037	251	31.93%	5.10	4.33	3.24
DBB-24	866	99	12.91%	1064	99	10.26%	834	99	13.47%	1.88	2.31	1.81
DBB-25	1011	66	6.98%	718	66	10.12%	636	66	11.58%	2.48	1.76	1.56
DBB-26	897	41	4.79%	883	41	4.87%	611	41	7.19%	2.99	2.94	2.04
DBB-27	2315	56	2.48%	706	56	8.62%	628	56	9.79%	3.11	0.95	0.84
DBB-28	1220	45	3.83%	1093	45	4.29%	918	45	5.15%	3.21	2.88	2.42
DBB-29	1251	179	16.70%	736	179	32.14%	656	179	37.53%	6.95	4.09	3.64
DBB-30	1778	659	58.89%	1628	659	68.01%	1394	659	89.66%	14.94	13.68	11.71
DBB-31	1117	23	2.10%	715	23	3.32%	593	23	4.04%	3.72	2.38	1.98
DBB-32	2708	80	3.04%	591	80	15.66%	516	80	18.35%	17.82	3.89	3.39
DBB-33	1349	83	6.56%	980	83	9.25%	747	83	12.50%	5.72	4.15	3.17
DBB-34	1132	198	21.20%	801	198	32.84%	933	198	26.94%	2.99	2.12	2.47
DBB-35	1117	165	17.33%	1156	165	16.65%	795	165	26.19%	3.72	3.85	2.65
DBB-36	1183	219	22.72%	945	219	30.17%	738	219	42.20%	6.65	5.31	4.15
DBB-37	3160	0	0.00%	678	0	0.00%	555	0	0.00%	30.38	6.52	5.34
DBB-38	1255	288	29.78%	1213	288	31.14%	958	288	42.99%	11.21	10.83	8.55
DBB-39	1156	-17	-1.45%	896	-17	-1.86%	718	-17	-2.31%	6.88	5.33	4.27

Reference	P Number	Location	Config	Total Beds	Total Project Cost	Inflation factor	Total Adjusted Barracks Project Cost with Other Costs	Cost per Bed with Other Costs
DB-1	133	ANNAPOLIS MD NAVACAD	1+1	40	$3,924,294	1.266014	$4,968,212.09	$124,205
DB-2	641/A	GREAT LAKES IL NH	2+2	410	$21,286,091	1.22125	$25,995,629.89	$63,404
DB-3	626	GREAT LAKES IL NSTC	2+2	660	$23,663,854	1.22125	$28,899,471.69	$43,787
DB-4	707	SAN DIEGO CA NAS NORTH IS	1+1	150	$17,099,261	1.22125	$20,882,465.00	$139,216
DB-5	326	WASHINGTON DC COMNAVDIST	1+1	250	$20,825,141	1.22125	$25,432,693.94	$101,731
DB-6	411	BEAUFORT SC MCAS	2+0	422	$13,536,175	1.201858	$16,268,561.80	$38,551
DB-7	023	CAMP PENDLETON CA MCB	2+0	320	$8,141,859	1.201858	$9,785,358.74	$30,579
DB-8	074	CAMP PENDLETON CA MCB	2+0	400	$12,187,136	1.201858	$14,647,208.04	$36,618
DB-9	646	GREAT LAKES IL NSTC	2+2	820	$26,571,549	1.201858	$31,935,231.51	$38,945
DB-10	410	YUMA AZ MCAS	2+0	350	$10,695,616	1.201858	$12,854,613.12	$36,727
DB-11	024	CAMP PENDLETON CA MCB	2+0	320	$10,403,182	1.174286	$12,216,312.51	$38,176
DB-12	999	CAMP PENDLETON CA MCB	2+0	400	$10,600,733	1.174286	$12,448,293.80	$31,121
DB-13	759	GULFPORT MS NCBC	1+1	214	$10,600,263	1.174286	$12,447,742.87	$58,167
DB-14	066	INGLESIDE TX NS	1+1	200	$10,088,658	1.174286	$11,846,971.72	$59,235
DB-15	555	SAN DIEGO CA NAS NORTH IS	1+1	90	$8,678,172	1.174286	$10,190,657.52	$113,230
DB-16	415	YUMA AZ MCAS	2+0	316	$9,597,235	1.174286	$11,269,899.99	$35,664
DB-17	069	CAMP PENDLETON CA MCB	2+0	200	$7,985,530	1.143707	$9,133,104.84	$45,666
DB-18	478	QUANTICO VA MCCOMBDEV CMD	2+0	600	$19,685,287	1.143707	$22,514,196.27	$37,524
DB-19	295	TWENTYNINE PALMS CA	2+0	124	$6,420,677	1.143707	$7,343,372.35	$59,221
DB-20	495	TWENTYNINE PALMS CA MAGCC	2+0	384	$16,596,625	1.143707	$18,981,672.51	$49,431
DB-21	159A	CAMP LEJEUNE NC MCB	2+0	400	$13,711,147	1.123303	$15,401,770.46	$38,504
DB-22	622	TWENTYNINE PALMS CA MAGCC	2+0	384	$15,269,071	1.123303	$17,151,790.76	$44,666
DB-23	990	WASH DC MARBARRACKS	2+0	332	$19,166,184	1.123303	$21,529,427.83	$64,848
DB-24	182	BRUNSWICK ME NAS	2+0	250	$19,978,219	1.088253	$21,741,362.51	$86,965
DB-25	893	CAMP LEJEUNE NC MCB	2+0	320	$12,547,447	1.088253	$13,654,800.62	$42,671
DB-26	135	CAMP LEJEUNE NC MCB	2+0	400	$15,084,892	1.088253	$16,416,183.64	$41,040

Reference	P Number	Location	Config	Total Beds	Total Project Cost	Inflation factor	Total Adjusted Barracks Project Cost with Other Costs	Cost per Bed with Other Costs
DB-27	017	CAMP PENDLETON CA MCB	2+0	400	$16,457,873	1.088253	$17,910,333.88	$44,776
DB-28	044	CAMP PENDLETON CA MCB	2+0	400	$16,104,840	1.088253	$17,526,144.99	$43,815
DB-29	234	EL CENTRO CA NAF	2+0	160	$18,116,839	1.088253	$19,715,709.72	$123,223
DB-30	763	GULFPORT MS NAVCONSTRACEN	1+1	180	$12,340,480	1.088253	$13,429,568.40	$74,609
DB-31	002	KANSAS CITY MO	2+0	196	$9,925,900	1.088253	$10,801,893.26	$55,112
DB-32	772	MAYPORT FL NS	1+1	260	$14,444,908	1.088253	$15,719,718.47	$60,460
DB-33	254	SAN DIEGO CA NAVSTA	1+1	516	$39,797,592	1.088253	$43,309,860.38	$83,934
DB-34	685	TWENTYNINE PALMS CA MAGCC	2+0	384	$22,895,173	1.088253	$24,915,747.76	$64,885
DB-35	093A	CAMP PENDLETON CA MCB	2+0	400	$17,297,120	1.062733	$18,382,226.75	$45,956
DB-36	120	PASCAGOULA MS NS	1+1	100	$10,470,665	1.062733	$11,127,525.56	$111,275
DB-37	623	TWENTYNINE PALMS CA MAGCC	2+0	384	$18,490,472	1.062733	$19,650,441.69	$51,173
DB-38	605	TWENTYNINE PALMS CA MAGCC	2+0	384	$21,286,091	1	$21,286,091.32	$55,433

Reference	P Number	Location	Config	Total Beds	Total Project Cost	Inflation factor	Total Adjusted Barracks Project Cost with Other Costs	Cost per Bed with Other Costs
DBB-1	083	EVERETT WA NAVSTA	2+2	232	$7,440,372	1.300494	$9,676,154.92	$41,708
DBB-2	708	NORFOLK VA NS	2+2	720	$17,018,075	1.300494	$22,131,896.40	$30,739
DBB-3	369	BEAUFORT SC MCAS	2+0	476	$17,286,055	1.266014	$21,884,391.19	$45,976
DBB-4	889	CAMP PENDLETON CA MCB	2+0	400	$12,279,468	1.266014	$15,545,980.98	$38,865
DBB-5	319	CORPUS CHRISTI TX NAS	1+1	96	$5,012,587	1.266014	$6,346,006.43	$66,104
DBB-6	584	NEW RIVER NC MCAS	2+0	322	$15,807,866	1.266014	$20,012,983.49	$62,152
DBB-7	488	PORT HUENEME CA NFELC	1+1	329	$21,286,091	1.266014	$26,948,494.62	$81,910
DBB-8	026	PORTSMOUTH VA NH	1+1	278	$11,124,400	1.266014	$14,083,648.45	$50,661
DBB-9	758	SUGAR GROVE WV NSGD	1+1	106	$8,386,761	1.266014	$10,617,759.08	$100,168
DBB-10	026	WILLIAMSBURG VA FISC CA	1+1	122	$5,956,370	1.266014	$7,540,848.65	$61,810
DBB-11	630	CAMP LEJEUNE NC MCB	2+2	200	$6,303,653	1.22125	$7,698,333.89	$38,492
DBB-12	070	CAMP PENDLETON CA MCB	2+0	360	$10,309,816	1.22125	$12,590,858.51	$34,975
DBB-13	016	CAMP PENDLETON CA MCB	2+0	320	$9,485,298	1.22125	$11,583,915.97	$36,200
DBB-14	287	CRANE IN NAVSURFWARCENDIV	1+1	72	$5,420,293	1.22125	$6,619,531.01	$91,938
DBB-15	272	DAHLGREN VA NSWCTR DIV	1+1	164	$9,837,154	1.22125	$12,013,619.77	$73,254
DBB-16	086	EVERETT WA NAVSTA	1+1	202	$10,468,307	1.22125	$12,784,414.99	$63,289
DBB-17	322	FALLON NV NAS	1+1	100	$12,979,221	1.22125	$15,850,868.43	$158,509
DBB-18	057	INGLESIDE TX NS	1+1	186	$8,932,228	1.22125	$10,908,479.82	$58,648
DBB-19	438	KANEOHE BAY HI MCB	2+0	300	$19,373,586	1.22125	$23,659,983.25	$78,867
DBB-20	422	NEW LONDON CT NSB	1+1	200	$11,628,278	1.22125	$14,201,029.91	$71,005
DBB-21	142	PEARL HARBOR HI NSB	1+1	358	$28,121,876	1.22125	$34,343,828.77	$95,932
DBB-22	439	KANEOHE BAY HI MCB	2+0	360	$18,344,105	1.201858	$22,047,010.83	$61,242
DBB-23	587	NEW RIVER NC MCAS	2+0	320	$10,422,936	1.201858	$12,526,890.66	$39,147
DBB-24	712	OCEANA VA NAS	1+1	460	$16,346,242	1.201858	$19,645,863.26	$42,708
DBB-25	286	KANEOHE BAY HI MCB	2+0	408	$24,961,589	1.174286	$29,312,048.58	$71,843
DBB-26	740	KANEOHE BAY HI MCB	2+0	300	$14,620,994	1.174286	$17,169,231.85	$57,231
DBB-27	002	MIRAMAR CA MCAS	1+1	744	$28,407,587	1.174286	$33,358,637.02	$44,837

Reference	P Number	Location	Config	Total Beds	Total Project Cost	Inflation factor	Total Adjusted Barracks Project Cost with Other Costs	Cost per Bed with Other Costs
DBB-28	174	BRUNSWICK ME NAS	1+1	380	$15,873,544	1.143707	$18,154,679.93	$47,775
DBB-29	003	DAM NECK VA	1+1	180	$9,740,228	1.143707	$11,139,964.68	$61,889
DBB-30	508	PORTSMOUTH VA NORFOLK NSY	2+2	119	$18,116,012	1.143707	$20,719,406.03	$174,113
DBB-31	741	KANEOHE BAY HI MCB	2+0	300	$18,013,592	1.123303	$20,234,718.46	$67,449
DBB-32	201	LEMOORE CA NAS	2+0	152	$8,076,009	1.123303	$9,071,803.93	$59,683
DBB-33	593	PEARL HARBOR HI NS	2+0	236	$15,387,636	1.123303	$17,284,974.54	$73,241
DBB-34	504	PORTSMOUTH VA NORFOLK NSY	2+0	378	$17,574,403	1.123303	$19,741,375.96	$52,226
DBB-35	748	KANEOHE BAY HI MCB	2+0	300	$25,421,276	1.088253	$27,664,787.31	$92,216
DBB-36	260	KITTERY ME PORTSMOUTH NSY	1+1	178	$13,879,252	1.088253	$15,104,141.39	$84,855
DBB-37	194	LEMOORE CA NAS	1+1	104	$7,089,910	1.088253	$7,715,618.07	$74,189
DBB-38	467	PEARL HARBOR HI NS	1+1	112	$15,857,752	1.088253	$17,257,251.24	$154,083
DBB-39	532	YORKTOWN VA NWS	1+1	168	$12,761,427	1.062733	$13,561,994.58	$80,726

Refer.	Demolition ($M)	Bldgs to Demo	Demo Cost/bldg ($M/bldg)	Other Costs ($M)	Total 1391 Estimate ($M)	% of Estimate Demo/other	Total Barracks Project Cost	Inflation factor	Total Adjusted Barracks Project Cost	Cost per Bed
DB-1	$0	0	$0	$0	$0	0%	$3,924,294	1.26601	$4,968,212	$124,205
DB-2	$0	0	$0	$0	$0	0%	$21,286,091	1.22125	$25,995,630	$63,404
DB-3	$0	0	$0	$0	$0	0%	$23,663,854	1.22125	$28,899,472	$43,787
DB-4	$940	0	$0	$2,760	$15,280	24%	$12,958,733	1.22125	$15,825,847	$105,506
DB-5	$0	0	$0	$3,930	$17,340	23%	$16,105,256	1.22125	$19,668,537	$78,674
DB-6	$270	0	$0	$0	$13,770	2%	$13,270,760	1.20186	$15,949,570	$37,795
DB-7	$840	0	$0	$0	$10,780	8%	$7,507,428	1.20186	$9,022,863	$28,196
DB-8	$0	0	$0	$0	$0	0%	$12,187,136	1.20186	$14,647,208	$36,618
DB-9	$487	0	$487	$0	$23,980	2%	$26,032,288	1.20186	$31,287,116	$38,155
DB-10	$350	2	$175	$150	$9,020	6%	$10,102,733	1.20186	$12,142,051	$34,692
DB-11	$0	0	$0	$0	$0	0%	$10,403,182	1.17429	$12,216,313	$38,176
DB-12	$0	0	$0	$0	$0	0%	$10,600,733	1.17429	$12,448,294	$31,121
DB-13	$550	4	$138	$0	$9,590	6%	$9,992,323	1.17429	$11,733,847	$54,831
DB-14	$0	0	$0	$0	$0	0%	$10,088,658	1.17429	$11,846,972	$59,235
DB-15	$380	7	$54	$60	$7,500	6%	$8,169,053	1.17429	$9,592,806	$106,587
DB-16	$150	2	$75	$0	$9,900	2%	$9,451,822	1.17429	$11,099,144	$35,124
DB-17	$0	0	$0	$0	$0	0%	$7,985,530	1.14371	$9,133,105	$45,666
DB-18	$410	2	$205	$0	$18,700	2%	$19,253,684	1.14371	$22,020,570	$36,701
DB-19	$230	2	$115	$0	$6,870	3%	$6,205,720	1.14371	$7,097,524	$57,238
DB-20	$320	2	$160	$0	$17,190	2%	$16,287,671	1.14371	$18,628,320	$48,511
DB-21	$0	0	$0	$0	$0	0%	$13,711,147	1.1233	$15,401,770	$38,504
DB-22	$400	2	$200	$0	$19,560	2%	$14,956,820	1.1233	$16,801,038	$43,753
DB-23	$0	0	$0	$2,990	$16,230	18%	$15,635,260	1.1233	$17,563,132	$52,901
DB-24	$340	3	$113	$0	$19,600	2%	$19,631,658	1.08825	$21,364,216	$85,457
DB-25	$0	4	$0	$0	$0	0%	$12,547,447	1.08825	$13,654,801	$42,671
DB-26	$120	0	$0	$0	$14,340	1%	$14,958,659	1.08825	$16,278,810	$40,697

Refer.	Demolition ($M)	Bldgs to Demo	Demo Cost/bldg ($M/bldg)	Other Costs ($M)	Total 1391 Estimate ($M)	% of Estimate Demo/other	Total Barracks Project Cost	Inflation factor	Total Adjusted Barracks Project Cost	Cost per Bed
DB-27	$140	0	$0	$670	$18,380	4%	$15,732,580	1.08825	$17,121,032	$42,803
DB-28	$0	11	$0	$120	$18,730	1%	$16,001,659	1.08825	$17,413,858	$43,535
DB-29	$160	3	$53	$0	$20,400	1%	$17,974,746	1.08825	$19,561,077	$122,257
DB-30	$260	2	$130	$0	$12,400	2%	$12,081,728	1.08825	$13,147,981	$73,044
DB-31	$190	1	$190	$0	$6,970	3%	$9,655,323	1.08825	$10,507,437	$53,609
DB-32	$0	0	$0	$0	$0	0%	$14,444,908	1.08825	$15,719,718	$60,460
DB-33	$980	0	$0	$0	$40,970	2%	$38,845,636	1.08825	$42,273,891	$81,926
DB-34	$150	0	$0	$0	$25,740	1%	$22,761,752	1.08825	$24,770,551	$64,507
DB-35	$90	0	$0	$230	$20,150	2%	$17,022,426	1.06273	$18,090,301	$45,226
DB-36	$0	0	$0	$1,510	$10,390	15%	$8,948,942	1.06273	$9,510,339	$95,103
DB-37	$460	0	$0	$0	$22,350	2%	$18,109,907	1.06273	$19,246,003	$50,120
DB-38	$300	2	$150	$0	$22,640	1%	$21,004,032	1	$21,004,032	$54,698

Refer.	Demolition ($M)	Bldgs to Demo	Demo Cost/bldg ($M/bldg)	Other Costs ($M)	Total 1391 Estimate ($M)	% of Estimate Demo/other	Total Barracks Project Cost	Inflation factor	Total Adjusted Barracks Project Cost	Cost per Bed
DBB-1	$0	0	$0	$0	$0	0%	$7,440,372	1.30049	$9,676,155	$41,708
DBB-2	$2,000	0	$0	$0	$14,760	14%	$14,712,103	1.30049	$19,132,994	$26,574
DBB-3	$713	10	$71	$0	$13,480	5%	$16,371,313	1.26601	$20,726,315	$43,543
DBB-4	$980	11	$89	$0	$10,720	9%	$11,156,904	1.26601	$14,124,800	$35,312
DBB-5	$0	0	$0	$0	$0	0%	$5,012,587	1.26601	$6,346,006	$66,104
DBB-6	$0	0	$0	$0	$0	0%	$15,807,866	1.26601	$20,012,983	$62,152
DBB-7	$1,000	3	$333	$0	$15,000	7%	$19,867,019	1.26601	$25,151,928	$76,450
DBB-8	$0	0	$0	$0	$0	0%	$11,124,400	1.26601	$14,083,648	$50,661
DBB-9	$0	0	$0	$0	$0	0%	$8,386,761	1.26601	$10,617,759	$100,168
DBB-10	$0	0	$0	$0	$0	0%	$5,956,370	1.26601	$7,540,849	$61,810
DBB-11	$110	1	$110	$0	$4,670	2%	$6,155,173	1.22125	$7,517,003	$37,585
DBB-12	$140	6	$120	$0	$10,600	1%	$10,173,649	1.22125	$12,424,564	$34,513
DBB-13	$213	3	$120	$0	$9,080	2%	$9,262,442	1.22125	$11,311,753	$35,349
DBB-14	$174	1	$174	$0	$4,490	4%	$5,210,242	1.22125	$6,363,006	$88,375
DBB-15	$328	1	$328	$0	$7,210	5%	$9,389,638	1.22125	$11,467,092	$69,921
DBB-16	$0	0	$0	$0	$0	0%	$10,468,307	1.22125	$12,784,415	$63,289
DBB-17	$413	0	$413	$0	$13,270	3%	$12,574,945	1.22125	$15,357,146	$153,571
DBB-18	$0	0	$0	$0	$0	0%	$8,932,228	1.22125	$10,908,480	$58,648
DBB-19	$940	3	$313	$0	$17,950	5%	$18,359,036	1.22125	$22,420,965	$74,737
DBB-20	$0	0	$0	$0	$0	0%	$11,628,278	1.22125	$14,201,030	$71,005
DBB-21	$626	2	$313	$0	$27,280	2%	$27,476,557	1.22125	$33,555,734	$93,731
DBB-22	$900	3	$300	$0	$16,990	5%	$17,372,374	1.20186	$20,879,129	$57,998
DBB-23	$200	2	$100	$0	$9,520	2%	$10,203,967	1.20186	$12,263,721	$38,324
DBB-24	$0	0	$0	$0	$0	0%	$16,346,242	1.20186	$19,645,863	$42,708
DBB-25	$0	0	$0	$0	$0	0%	$24,961,589	1.17429	$29,312,049	$71,843
DBB-26	$900	3	$300	$0	$16,990	5%	$13,846,486	1.17429	$16,259,738	$54,199
DBB-27	$990	9	$110	$0	$26,570	4%	$27,349,118	1.17429	$32,115,692	$43,166

Refer.	Demolition ($M)	Bldgs to Demo	Demo Cost/bldg ($M/bldg)	Other Costs ($M)	Total 1391 Estimate ($M)	% of Estimate Demo/other	Total Barracks Project Cost	Inflation factor	Total Adjusted Barracks Project Cost	Cost per Bed
DBB-28	$1,040	6	$173	$0	$15,170	7%	$14,785,311	1.14371	$16,910,061	$44,500
DBB-29	$0	0	$0	$0	$0	0%	$9,740,228	1.14371	$11,139,965	$61,889
DBB-30	$410	1	$410	$0	$15,840	3%	$17,647,100	1.14371	$20,183,108	$169,606
DBB-31	$450	0	$0	$0	$17,280	3%	$17,544,488	1.1233	$19,707,773	$65,693
DBB-32	$180	0	$0	$0	$7,790	2%	$7,889,401	1.1233	$8,862,186	$58,304
DBB-33	$480	0	$0	$0	$15,490	3%	$14,910,808	1.1233	$16,749,352	$70,972
DBB-34	$390	1	$390	$0	$15,190	3%	$17,123,184	1.1233	$19,234,520	$50,885
DBB-35	$530	0	$0	$1,410	$22,290	9%	$23,208,747	1.08825	$25,256,995	$84,190
DBB-36	$0	0	$0	$0	$0	0%	$13,879,252	1.08825	$15,104,141	$84,855
DBB-37	$0	0	$0	$0	$0	0%	$7,089,910	1.08825	$7,715,618	$74,189
DBB-38	$1,160	0	$0	$0	$14,950	8%	$14,627,318	1.08825	$15,918,227	$142,127
DBB-39	$610	2	$305	$0	$13,030	5%	$12,164,000	1.06273	$12,927,089	$76,947

Reference	Location	Original Project Cost	Final Project Cost	Cost Growth	EFD/EFA
DB-1	ANNAPOLIS MD NAVACAD	$3,465,842	$3,706,719	6.95%	Chesapeake
DB-2	GREAT LAKES IL NH	$20,004,323	$20,088,029	0.42%	South
DB-3	GREAT LAKES IL NSTC	$22,351,358	$22,325,114	-0.12%	South
DB-4	SAN DIEGO CA NAS NORTH IS	$15,826,024	$16,137,976	1.97%	Southwest
DB-5	WASHINGTON DC COMNAVDIST	$18,858,709	$19,661,740	4.26%	Chesapeake
DB-6	BEAUFORT SC MCAS	$12,472,397	$12,764,676	2.34%	South
DB-7	CAMP PENDLETON CA MCB	$7,633,493	$7,679,580	0.60%	Southwest
DB-8	CAMP PENDLETON CA MCB	$11,390,299	$11,503,930	1.00%	Southwest
DB-9	GREAT LAKES IL NSTC	$25,104,020	$25,065,308	-0.15%	South
DB-10	YUMA AZ MCAS	$9,888,531	$10,089,564	2.03%	Southwest
DB-11	CAMP PENDLETON CA MCB	$9,805,342	$9,816,640	0.12%	Southwest
DB-12	CAMP PENDLETON CA MCB	$9,907,326	$10,002,568	0.96%	Southwest
DB-13	GULFPORT MS NCBC	$9,701,848	$9,998,169	3.05%	South
DB-14	INGLESIDE TX NS	$9,541,000	$9,517,602	-0.25%	South
DB-15	SAN DIEGO CA NAS NORTH IS	$8,116,269	$8,187,464	0.88%	Southwest
DB-16	YUMA AZ MCAS	$8,782,000	$9,053,656	3.09%	Southwest
DB-17	CAMP PENDLETON CA MCB	$7,544,233	$7,543,596	-0.01%	Southwest
DB-18	QUANTICO VA MCCOMBDEV CMD	$17,644,493	$18,573,023	5.26%	Chesapeake
DB-19	TWENTYNINE PALMS CA	$5,955,699	$6,061,150	1.77%	Southwest
DB-20	TWENTYNINE PALMS CA MAGCC	$15,567,578	$15,677,716	0.71%	Southwest
DB-21	CAMP LEJEUNE NC MCB	$13,078,070	$12,924,606	-1.17%	Atlantic
DB-22	TWENTYNINE PALMS CA MAGCC	$14,411,554	$14,408,458	-0.02%	Southwest
DB-23	WASH DC MARBARRACKS	$17,012,710	$18,093,154	6.35%	Chesapeake
DB-24	BRUNSWICK ME NAS	$18,662,961	$18,849,262	1.00%	North
DB-25	CAMP LEJEUNE NC MCB	$13,853,529	$14,227,491	2.70%	Atlantic
DB-26	CAMP LEJEUNE NC MCB	$11,743,336	$11,840,036	0.82%	Atlantic
DB-27	CAMP PENDLETON CA MCB	$15,420,147	$15,538,264	0.77%	Southwest
DB-28	CAMP PENDLETON CA MCB	$14,988,248	$15,200,912	1.42%	Southwest

Reference	Location	Original Project Cost	Final Project Cost	Cost Growth	EFD/EFA
DB-29	EL CENTRO CA NAF	$16,371,763	$17,129,322	4.63%	Southwest
DB-30	GULFPORT MS NAVCONSTRACEN	$11,277,102	$11,644,781	3.26%	Southwest
DB-31	KANSAS CITY MO	$9,263,714	$9,365,399	1.10%	South
DB-32	MAYPORT FL NS	$13,455,763	$13,629,904	1.29%	South
DB-33	SAN DIEGO CA NAVSTA	$37,563,268	$37,564,468	0.00%	Southwest
DB-34	TWENTYNINE PALMS CA MAGCC	$21,280,628	$21,612,817	1.56%	Southwest
DB-35	CAMP PENDLETON CA MCB	$15,776,646	$16,320,622	3.45%	Southwest
DB-36	PASCAGOULA MS NS	$9,406,891	$9,884,455	5.08%	South
DB-37	TWENTYNINE PALMS CA MAGCC	$16,091,672	$17,449,111	8.44%	Southwest
DB-38	TWENTYNINE PALMS CA MAGCC	$20,004,323	$20,088,029	0.42%	Southwest

Reference	Location	Original Project Cost	Final Project Cost	Cost Growth	EFD/EFA
DBB-1	EVERETT WA NAVSTA	$6,523,059	$7,024,493	7.69%	West
DBB-2	NORFOLK VA NS	$14,388,953	$16,061,226	11.62%	Atlantic
DBB-3	BEAUFORT SC MCAS	$15,544,980	$16,309,681	4.92%	South
DBB-4	CAMP PENDLETON CA MCB	$10,978,497	$11,583,009	5.51%	Southwest
DBB-5	CORPUS CHRISTI TX NAS	$4,630,423	$4,733,558	2.23%	South
DBB-6	NEW RIVER NC MCAS	$14,798,107	$14,895,660	0.66%	Atlantic
DBB-7	PORT HUENEME CA NFELC	$20,004,323	$20,088,029	0.42%	Southwest
DBB-8	PORTSMOUTH VA NH	$10,103,604	$10,495,849	3.88%	Atlantic
DBB-9	SUGAR GROVE WV NSGD	$7,617,898	$7,917,315	3.93%	Atlantic
DBB-10	WILLIAMSBURG VA FISC CA	$5,375,760	$5,624,266	4.62%	Atlantic
DBB-11	CAMP LEJEUNE NC MCB	$5,960,829	$5,939,120	-0.36%	Atlantic
DBB-12	CAMP PENDLETON CA MCB	$8,804,404	$8,952,128	1.68%	Southwest
DBB-13	CAMP PENDLETON CA MCB	$9,547,058	$9,729,141	1.91%	Southwest
DBB-14	CRANE IN NAVSURFWARCENDIV	$4,899,521	$5,116,825	4.44%	South
DBB-15	DAHLGREN VA NSWCTR DIV	$8,844,411	$9,280,344	4.93%	Chesapeake
DBB-16	EVERETT WA NAVSTA	$9,743,898	$9,872,371	1.32%	Southwest
DBB-17	FALLON NV NAS	$12,379,296	$12,213,485	-1.34%	Southwest
DBB-18	INGLESIDE TX NS	$8,222,906	$8,429,603	2.51%	South
DBB-19	KANEOHE BAY HI MCB	$17,799,633	$18,177,885	2.13%	Pacific
DBB-20	NEW LONDON CT NSB	$10,100,625	$10,580,106	4.75%	North
DBB-21	PEARL HARBOR HI NSB	$25,737,682	$26,397,107	2.56%	Pacific
DBB-22	KANEOHE BAY HI MCB	$16,820,591	$17,224,206	2.40%	Pacific
DBB-23	NEW RIVER NC MCAS	$9,587,622	$9,830,274	2.53%	Atlantic
DBB-24	OCEANA VA NAS	$12,911,561	$15,429,983	19.51%	Atlantic
DBB-25	KANEOHE BAY HI MCB	$23,040,619	$23,438,355	1.73%	Pacific
DBB-26	KANEOHE BAY HI MCB	$12,954,240	$13,728,188	5.97%	Pacific
DBB-27	MIRAMAR CA MCAS	$26,335,051	$26,805,417	1.79%	Southwest
DBB-28	BRUNSWICK ME NAS	$16,007,278	$14,890,600	-6.98%	North

Reference	Location	Original Project Cost	Final Project Cost	Cost Growth	EFD/EFA
DBB-29	DAM NECK VA	$8,164,242	$9,191,547	12.58%	Atlantic
DBB-30	PORTSMOUTH VA NORFOLK NSY	$15,962,738	$17,094,134	7.09%	Atlantic
DBB-31	KANEOHE BAY HI MCB	$16,282,451	$16,915,351	3.89%	Pacific
DBB-32	LEMOORE CA NAS	$7,484,859	$7,625,695	1.88%	Southwest
DBB-33	PEARL HARBOR HI NS	$13,945,204	$14,451,684	3.63%	Pacific
DBB-34	PORTSMOUTH VA NORFOLK NSY	$15,921,671	$16,588,354	4.19%	Atlantic
DBB-35	KANEOHE BAY HI MCB	$22,594,455	$23,880,086	5.69%	Pacific
DBB-36	KITTERY ME PORTSMOUTH NSY	$12,250,000	$12,957,006	5.77%	North
DBB-37	LEMOORE CA NAS	$6,593,454	$6,697,699	1.58%	Southwest
DBB-38	PEARL HARBOR HI NS	$13,554,042	$14,893,611	9.88%	Pacific
DBB-39	YORKTOWN VA NWS	$11,636,863	$12,046,750	3.52%	Atlantic

Appendix B: Detailed Description of Identification of Data Sample

B.1 How Data were Obtained

All data for this thesis was obtained through various offices of Naval Facilities Engineering Command (NAVFAC). A request was made for data pertaining to all Military Construction (MILCON) projects to enable a comparison of DBB and DB projects. The data was originally restricted to projects approved by Congress for fiscal years 1997 to 2003. The data was exported from Financial Information System (FIS) database into a spreadsheet. The data fields included description, location, contract type (DBB or DB), original contract amount, final contract amount, original project start date, project completion date, and category code. A category code (CATCODE) is a unique five digit number that specifies the type of primary facility to be built or renovated. The author wanted to compare similar facilities that were either DBB or DB.

Through the use of filters, each CATCODE was analyzed to determine which CATCODE had the most projects. CATCODE's 72111, 72114, 72115, and 72124 are all related to Bachelor Enlisted Quarters (BEQ's). Fifty-four DB projects and forty-seven DBB projects were found in these CATCODE's. More specific project information was requested for all projects in these CATCODE's for MILCON projects approved in fiscal year 1995 to 2004. The data for these BEQ MILCON's were exported from FIS into a spreadsheet.

The majority of the data collected is from this spreadsheet, however a few notable gaps in the data existed. No data for the design portion of the DBB projects was captured. To obtain this information the author was granted access to FIS via the internet and used terminal emulation software to access the database. The design contract data was difficult to obtain from the database and accurate design start dates were not usually apparent.

Through more research, a different source of data was obtained. Project schedule and cost data can also be found in eProjects. After obtaining a username and password, design start dates and total project costs were obtained from eProjects.

The data from FIS and eProjects did not provide a detailed description of each project. Project descriptions, cost estimate information and other information are contained in the DD Form 1391 planning documents. NAVFAC has posted all "as enacted" DD Form 1391's for fiscal years 2000 to 2005. The DD Form 1391's were obtained by accessing the website via a computer on a navy.mil domain. No electronic source could be located for the DD Form 1391's for fiscal years 1995 to 1999. This data was obtained from reference copies located at NAVFAC Headquarters at the Washington DC Navy Yard.

Any information that could not be gathered from these sources was collected through interviews.

B.2 FIS, eProjects, DD Form 1391

All data were gathered from the Naval Facilities Engineering Command (NAVFAC). This data originated from three sources. Financial Information Systems (FIS) provided the bulk of the data. FIS is a mainframe application that “provides funds management, project accounting, and contract accounting for managing construction projects” (Woodie, 2004).

Since FIS was developed as a financial database, finding all project related data required viewing multiple screens that had small amounts of applicable project information on each screen. At the same time NAVFAC realized that having numerous databases doing specialized functions was causing inefficiencies. Furthermore, various commands had created their own databases to manage information that NAVFAC-wide databases did not enable them to easily manage. For these reasons, NAVFAC created an enterprise web-based system called eProject.

eProject is a web-based project management software that enables the user to input data as well as to view data in a simple-to-use format that is tailored for project specific details. The system enables viewing of the project history in addition to the current status. This software accesses data from a variety of sources including FIS, MS Projects and the facilities management software (Woodie, 2004). eClient is a low cost, web-based system that allows clients to request, track and evaluate projects. (ieFACMAN, 2005). eClient's “Project Status Report” (Appendix C) was used to determine associated design start dates for DBB projects. These reports were also used to confirm FIS data as well as locating points of contacts for projects that had unusual or incomplete data.

As-enacted DD Form 1391's were gathered for all of the sample projects from NAVFAC HQ. The number of beds, the configuration of the rooms and the percent of the estimated demolition and non-construction related costs were taken directly from these DD Form 1391's.

B.3 Determining which projects to include in the sample

One hundred and thirty-one projects were found in FIS that were authorized between 1995 and 2004 and had CATCODE's of either 72111, 72114, 72115, or 72124. During the analysis of the data many of the original projects were not considered.

Thirteen projects are open bay barracks. Open bay barracks are used for Sailors and Marines in basic training and are comprised of large open rooms with over 50 bunk beds and lockers in each room. One common bathroom/shower facility is shared by those living in that area. These barracks were not considered since the interiors of these buildings are vastly different from the other barracks. Unlike the barracks in the sample, open bay barracks have a centralized location of the bathroom/shower facility, a significantly higher density of beds, and the heating and cooling systems requirements are significantly different since an open bay must be temperature controlled versus numerous smaller rooms.

Fourteen projects were renovations to existing buildings. The cost for renovation is significantly different since the building shell already exists. The extent of renovation could also vary widely from only a minor upgrade to a complete overhaul where only the structural members remain from the original building. Therefore these projects were not considered.

Eight projects would not finish in time and were not considered. Two projects were built for the Air Force. Since the Air Force has different standards for their barracks these projects were not considered.

Two projects had duplicate entries. The same project for barracks in Port Hueneme, California, and Great Lakes, Illinois were listed in two different fiscal years. The contract numbers, the project start date, original completion date and final completion date were the same for each pair of line items in the spreadsheet. The DD Form 1391's for these projects were reviewed. They indicated that the projects requested money from Congress in two separate fiscal years due to phasing of the project, but the projects were to build the same buildings. Therefore the line items with different fiscal years were combined. The original project cost, the final project cost, and the total project cost for each line item were added together to obtain the project costs. After adding these costs, the project costs were similar to the estimates on the DD Form 1391's.

Thirteen projects were located overseas. Due to such differentiating factors as foreign currency fluctuations, differing costs for labor, and varying availability of materials, these projects were not considered.

After all of these projects were removed 77 projects remained. These projects were divided into two samples based upon the project delivery method chosen. The DBB sample contained 38 projects. The DB sample contained 37 projects.

B.4 Obtaining final data set

The data received from FIS showed several sets of fields that could be interpreted as the same data. For example, “CCDLEG” (Contract Completion Date – Legal) or “BOD ACT” (Beneficial Occupancy Date – Actual) could be used as the date the project ended. The following section will describe decisions made to develop the final data set.

The basis for time growth will compare the original project duration with the final project duration. To obtain the original project duration, the difference between the date of project award and the original project completion was found. The project start date for DBB projects used the “Design Contract Award” field from eProjects. Two fields existed that could be interpreted as the original project completion date—Contract Completion Date Legal-Original (CCDL O) and Contract Completion Date-Planned (CCDPLN). Based upon analysis of FIS and eProject data, “CCDL O” was determined to be the most accurate date, since CCDPLN was almost always the same date or later. This agrees with the belief that "CCDPLN" is moved as the contract is modified. The dates for "CCDL O" from FIS were corroborated by the eProjects data. Therefore the total project duration for DBB projects included the length of the design contract, the length of solicitation and award of the construction contract, and length of the construction contract.

The project start date for the DB projects used the actual contract award date (AWDACT in FIS). For the project completion date the same field was used as above. Therefore the total project duration included the length of the contract for the design and construction of the project.

The final project duration will be calculated as the difference between the date of project award and the actual project completion. The project award date was determined as described above. Two fields existed for possible dates of final contract completion – Contract Completion Date - Legal (CCDLEG) or Beneficial Occupancy Date – Actual (BODACT). The majority of "BODACT" fields were empty. CCDLEG was used as the final contract completion dates unless the BODACT field was filled in for eProjects and/or FIS in which case BODACT was used as the completion date.

The change in project duration was calculated as the difference between the final project duration and the original project duration. The percent change in project duration was calculated by dividing the change in project duration by the original project duration.

To determine cost growth the original project cost was subtracted from the final project cost. FIS and eProjects show different costs for these contracts. Based upon an interview, it was determined that this difference can be attributed to (waiting for the interview… The original and final project cost data was acquired from FIS. (CONOOBL/CONOBL vs. eProj CONOOBL/CONOBL; I think it is better to use FIS data.

Cost per bed was determined based on the adjusted project cost divided by the number of beds. The adjusted project cost was determined by adjusting the total barracks project cost for inflation as described below. The total barracks project cost was determined to be the sum of the design cost, construction cost and miscellaneous costs. This field was entitled “PROJOBL” in the FIS data. This number is greater than CONOBL since CONOBL only includes construction costs for DBB projects or design and construction costs for DB projects. Miscellaneous costs that were not included in the construction contract (CONOBL) could be for a routine item such as paying the local telephone company to install their infrastructure. These costs could also include a separate contract to another construction contractor to complete work that a defaulted contractor could not complete.

Appendix C: Example of a Project Status Report

Project Status

Client Project No.	002	**NAVFAC Workorder No.**	17438
NAVFAC ALnO	Dodds, David P 843-820-7087	**NAVFAC PM**	Worthy, James E 843-820-7391
Project Name	BACHELOR ENLISTED QUARTERS		
Project Year	2002	**P-Number**	002
Project Location	MCSPTACT KANSAS CITY MO		
Location Specifics			
Project Description	002|M67386		
Designer	GUERNSEY, C. H. & CO.		
Contractor	M. A. MORTENSON COMPANY		

Construction Cost Data

Appropriated Amount	$8,914,000
CWE (Construction)	$9,928,229
SIOH	6%

Project Schedule

	Original Planned Date	Current Planned Date	Actual Date
Design / Proposal Development Phase			
AE Award			02/06/02
Design Release		03/19/02	03/19/02
Solicitation Phase			
Auth to Advertise		03/15/02	03/15/02
Bid / Proposal Due			
Construction Phase			
Construction Contract Award		01/31/03	01/31/03
Beneficial Occupancy (BOD)		07/09/04	05/26/04
Next Critical Action			
Construction Start		01/31/03	

Construction Contract Information — Contract Number N6895002C0053

Contract Completion Date (CCD)		Contract Amount	
Original Legal CCD	06/15/04	**Original**	$9,240,000
Revised Legal CCD	06/15/04	**Revised**	$9,775,759
Original Duration	516	**Total Modifications**	$535,759
Revised Duration	516	**Cost Growth**	6%
Time Extension	0	**Pending Modifications**	$0
Schedule Growth	0%	**% Complete**	99%
% Elapsed	100%		

Client Expectations

Factor \ Weight	Initial	Latest	Comments
Timeliness			
Quality			
Cost			
Delivery			

Appendix D: Example of a DD Form 1391

1. Component NAVY	FY 2002 MILITARY CONSTRUCTION PROGRAM	2. Date 1/18/02

3. Installation and Location/UIC: M67443 MARINE CORPS SUPPORT ACTIVITY KANSAS CITY, MISSOURI	4. Project Title BACHELOR ENLISTED QUARTERS

5. Program Element	6. Category Code	7. Project Number	8. Project Cost
0206496M	721.24	002	Auth 9,010 Appr 8,914 Auth for Appr 9,010

9. COST ESTIMATES

Item	U/M	Quantity	Unit Cost	Cost ($000)
BACHELOR ENLISTED QUARTERS (44,832 SF)	m2	4,165	-	6,970
BACHELOR ENLISTED QUARTERS (44,832 SF)	m2	4,165	1,636	(6,810)
INFORMATION SYSTEM	LS	-	-	(70)
TECHNICAL OPERATING MANUALS	LS	-	-	(90)
SUPPORTING FACILITIES	LS	-	-	850
ELECTRICAL UTILITIES	LS	-	-	(60)
MECHANICAL UTILITIES	LS	-	-	(50)
PAVING AND SITE IMPROVEMENT	LS	-	-	(340)
ANTI-TERRORISM/FORCE PROTECTION	LS	-	-	(210)
DEMOLITION	LS	-	-	(190)

SUBTOTAL	-	-	-	7,820
Contingency (5.0%)	-	-	-	390

TOTAL CONTRACT COST	-	-	-	8,210
Supervision Inspection & Overhead (6.0%)	-	-	-	490

SUBTOTAL	-	-	-	8,700
DESIGN BUILD DESIGN COSTS	LS	-	-	310
GENERAL REDUCTION	LS	-	-	-96

TOTAL REQUEST	-	-	-	8,914
EQUIPMENT FROM OTHER APPROPRIATIONS		-	(NON-ADD)	-

10. Description of Proposed Construction

Construct a multi-story reinforced concrete masonry building with wind load upgrades, service elevator, concrete foundation and floors, and standing seam metal roofing, providing 98 rooms with semi-private bathrooms in the standard 2X0 room configuration. Building will be moment resisting steel frame with concrete masonry unit (CMU) in-fill walls (split faced block exterior), interior (CMU) walls, two-way reinforced concrete slabs and open web steel joist roof support.

Community, and service core areas consist of laundry facilities, lounges, administrative offices, housekeeping areas and public restrooms. Electrical systems include fire alarms, energy saving electronic monitoring and control system (EMCS), and information systems. Mechanical

(Continued On DD 1391C)

1. Component NAVY	FY 2002 MILITARY CONSTRUCTION PROGRAM	2. Date 1/18/02

3. Installation and Location/UIC: M67443
MARINE CORPS SUPPORT ACTIVITY KANSAS CITY, MISSOURI

4. Project Title BACHELOR ENLISTED QUARTERS	7. Project Number 002

(...continued)

systems include plumbing, fire protection systems, heating ventilation and air conditioning. Supporting facilities work includes site and building utility connections (water, sanitary and storm sewers, electrical, telephone, local area network (LAN), and cable television). Paving and site improvements include paved parking, sidewalks, multipurpose rooms, outdoor recreation facilities/courts, roadways access, bus shelter/turnouts, and replacement of asphalt paving for parade and drill field, earthwork, grading and landscaping. Also includes technical operating manuals; Anti-Terrorism/Force Protection features, relocation of an existing tennis court; and demolition of an existing inadequate barracks building involving asbestos and lead removal.

Maximum utilization: 196 E1-E3.
Intended Grade Mix: 22 E1-E3, 47 E-4, 40 E5.
Total: 109 persons.

11. Requirement: 130 PN Adequate: 0 PN Substandard: 0 PN

PROJECT:

Provides 98 2x0 configured rooms for permanent party enlisted personnel. (Current mission)

REQUIREMENT:

Project is required to provide adequate billeting for enlisted personnel at MCSA Kansas City, MO. This project also supports the Commandant's goal to replace all inadequate bachelor quarters with 2x0 configured barracks.

CURRENT SITUATION:

There are no facilities at MCSA Kansas City that meet quality of life requirements for bachelor enlisted personnel. The existing facility was constructed in the 1950's by the Air Force. It is a wood, asbestos sided building originally designed as an open squad bay barracks. It is costly to operate and maintain and has life, safety, fire, wind-load and environmental concerns, including lead paint and asbestos. Renovation costs would exceed new construction limits and would not meet current Anti-Terrorism / Force Protection (AT/FP) guidance.

IMPACT IF NOT PROVIDED:

Junior enlisted personnel will continue to be housed in deteriorated, and

1. Component NAVY	FY 2002 MILITARY CONSTRUCTION PROGRAM	2. Date 1/18/02

3. Installation and Location/UIC: M67443
MARINE CORPS SUPPORT ACTIVITY KANSAS CITY, MISSOURI

4. Project Title BACHELOR ENLISTED QUARTERS	7. Project Number 002

(...continued)

inadequate barracks to the detriment of their morale, retention and readiness. An inequitable amount of maintenance dollars will continue to be diverted from training facilities to barracks, which will exacerbate growing readiness and training problems and increase exponentially over time as existing buildings deteriorate further.

12. Supplemental Data:

A. Estimated Design Data: (Parametric estimates have been used to develop project costs. Project design conforms to Part II of Military Handbook 1190, Facility Planning and Design guide)

(1) Status:
- (A) Date Design Started.................................. 06/01
- (B) Date Design 35% Complete.......................... 08/02
- (C) Date Design Complete.............................. 10/02
- (D) Percent Complete As Of September 2000............. 2%
- (E) Percent Complete As Of January 2001............... 2%
- (F) Type of Design Contract........................... Design Build
- (G) Parametric Estimate used to develop cost.......... Yes
- (H) Energy study/life-cycle analysis performed........ Yes

(2) Basis:
- (A) Standard or Definitive Design: No
- (B) Where Design Was Most Recently Used: N/A

(3) Total Cost (C) = (A) + (B) Or (D) + (E):
- (A) Production of Plans and Specifications............ 235
- (B) All Other Design Costs............................ 78
- (C) Total... 313
- (D) Contract.. 78
- (E) In-House.. 235

(4) Contract Award.. 06/02

(5) Construction Start.................................... 08/02

(6) Construction Completion............................... 07/04

B. Equipment associated with this project which will be provided from other appropriations: NONE.

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VITA

Darren Russell Hale was born May 14, 1973 in Kansas City, Missouri, the son of Vickie and John Hale. Upon graduation from Shawnee Mission West High School in Overland Park, Kansas, Darren attended the University of Washington in Seattle for a year before transferring to Vanderbilt University. He received a Bachelor of Science Degree in Civil Engineering in December 1995. Upon graduation he was commissioned as an Ensign in the United States Navy. His tours of duty have included Deck Division Officer on USS MOUNT WHITNEY, Technical Information Center Division Officer on USS NIMITZ, Assistant Resident Officer in Charge of Construction and Program Management Officer. He currently holds the rank of Lieutenant and is a registered Professional Engineer in the State of Texas. In August 2004, he entered the Graduate School at The University of Texas.

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