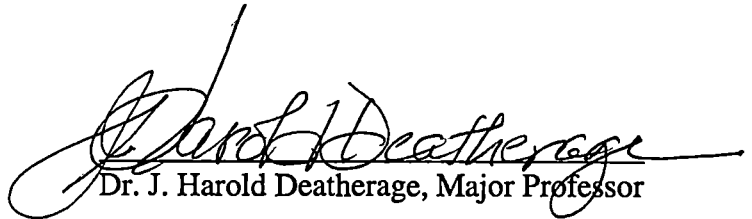


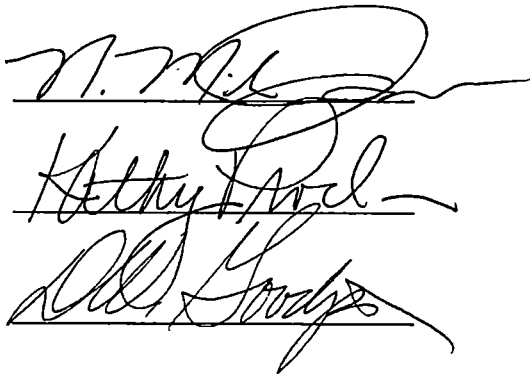
To the Graduate Council:

I am submitting herewith a thesis written by Melinda Dawn Carlisle entitled "The Design-Build Project Delivery System." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Civil Engineering.



Dr. J. Harold Deatherage, Major Professor

We have read this thesis
and recommend its acceptance:



Accepted for the Council:



Associate Vice Chancellor and
Dean of The Graduate School

THE DESIGN-BUILD PROJECT DELIVERY SYSTEM

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Melinda Dawn Carlisle
December 1999

DEDICATION

This thesis is dedicated to my parents

Mr. Joseph Lee Carlisle

and

Mrs. Rhonda Cheryl Carlisle

Standing in the spotlight, knowing that you were out there listening, I remember several times that I was so afraid, I didn't think I had the courage to stand up on this stage, then you reached into my heart and you found the courage. If there ever was somebody who made me believe in me, it was you. It was your words that made me persevere, it was your voice that gave me wings, it was your light that shined guiding my heart to find this place where I belong, it was your words... Anytime I doubt myself, I think of you because dreams can come true with God's great angels like you...*(Inspired by the words of Garth Brooks)*

and

To The Loving Memory of

Mrs. Goldia T. Grindstaff

The true measure of life is how long you exist after you've gone. You will live forever in many and forever in me...

And mostly, thanks to God, for it is through Him that all things are possible.

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Finally, I would like to send my thanks to the South Carolina Department of Transportation (SCDOT) and the Hardaway Construction Corporation of Tennessee (HCCT). Their cooperation has made this research possible.

ABSTRACT

The design-build project delivery system possesses fundamental advantages over other project delivery methods practiced in the United States. Design-build is a project delivery system wherein a single entity provides comprehensive design and construction services to an owner, under one contract. When properly applied and administered, design-build has the potential to improve quality, lower costs, lessen delivery time, reduce adversity, and foster innovation in the design and construction industry.

The purpose of this research study was to analyze cost and schedule performance of the design-build delivery system for highway and building construction projects. The research also identified important aspects of design-build projects such as communication, teamwork, insurance, bonding, and areas where potential problems can occur.

The study showed that design-build highway and building construction projects saved time and money over the design-bid-build project delivery system. Project delivery speed was increased for the design-build bridge projects studied. Unit prices were slightly higher for design-build bridge construction projects than the design-bid-build bridge construction projects analyzed. Cost savings are incurred by life-cycle costs and user costs. There was also reported higher level of commitment, communication, and teamwork for the design-build projects than the design-bid-build projects.

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CHAPTER ONE

INTRODUCTION

The design-build project delivery system possesses fundamental advantages over other project delivery methods practiced in the United States. Design-build is a project delivery system wherein a single entity provides comprehensive design and construction services to an owner, under a single contract. When properly applied and administered, design-build has the potential to improve quality, lower costs, lessen delivery time, reduce adversity, and foster innovation in the design and the construction industry.

With design-build, the designer and the constructor are joined in a relationship that provides clear incentives for cooperation. The design-build team is motivated towards achieving quality and cost effective solutions consistent with professional practice and project criteria. Adversarial relationships and complications are replaced by cooperative team efforts.

The complicated processes of design documentation and project construction are facilitated and delivery time shortened, when these two closely related activities are physically and contractually enjoined. Firm costs can be established earlier in the process and managed more successfully throughout the life of a project when a single entity bears this responsibility.

Generally design-build is applicable to all types of projects, regardless of size and complexity. Scope and criteria changes can be effectively and expeditiously managed with the participation of the total team: owner, designer and constructor.

A must for a successful design-build team is to have a well established trust amongst the team members and an outstanding reputation for quality and conscientiousness to the general public.

Design-build is becoming the preferred method for construction projects, due to the many reasons previously discussed. A lot of federal agencies and private owners are going with the design-build method. There is an enormous opportunity for an increased number of projects in the future.

1.1 OBJECTIVES

The purpose of this research study was to analyze schedule and cost performance of the design-build delivery system for several highway and building construction projects and to identify other important aspects of the design-build delivery system. This research had three main objectives:

1. To collect project cost and schedule data of highway and building construction projects.

2. To compare total project cost and schedule performance between the design-build and design-bid-build delivery systems.
3. To identify some of the important aspects of the design-build delivery system.

1.1.1 SCOPE

The scope of the study was to measure cost and schedule performances of select highway and building construction projects. The highway construction projects analyzed were all South Carolina Department of Transportation (SCDOT) projects. Hardaway Construction Corporation of Tennessee performed the building construction projects studied. Important processes and aspects of the design-build projects were also identified and analyzed. The definitions of each project delivery system are discussed in Chapter Two.

1.1.2 RELEVANCE

A study that investigates cost and schedule performance of highway and building design-build construction projects was warranted for many reasons. Very often on state funded highway construction projects, the two critical factors of a project are time and money. Public agencies have been frustrated by a history of poorly performing design-bid-build projects (1). This study will benefit potential owners by offering an objective investigation of cost and schedule performance of other highway construction projects.

This can assist owners in considering the design-build delivery system for their next project. General contractors and design professionals will also benefit from this study. By providing empirical data, a contractor or design professional will be more informed of the cost and schedule performances of design-build highway and building construction projects. Important aspects of design-build are identified; such as communication, teamwork, insurance and bonding to indicate differences from the traditional delivery systems. This study also provides caveats for the owner, contractor, design professional and the design-build team for their future project success.

1.2 RESEARCH APPROACH

In the first phase of this study, data was collected by means of personal interviews, electronic mail, and telephone interviews. Data was obtained from the South Carolina Department of Transportation, Hardaway Construction Corporation of Tennessee, involved contractors and design professionals.

The second phase of the study involved analyzing and verifying the cost and schedule performance data. The data was then compared to the traditional delivery system. Conclusions were made concerning cost and schedule performance.

The third phase of the study investigated the important aspects of design-build projects. Communication, teamwork, insurance and bonding were the major areas explored. These factors were then compared to the traditional delivery system.

The final phase of the study identified caveats for involved parties based on lessons learned on the cases studied in this project and in the industry.

1.3 CASE STUDIES RESEARCHED

1.3.1 HIGHWAY CONSTRUCTION

The SCDOT has participated in five design-build highway construction projects. Background information of these case studies is outlined below.

Enoree River Bridge

In August 1995, Tropical Storm Jerry destroyed two vital bridges in South Carolina. The Federal Highway Administration approved Emergency Relief funds to replace the existing damaged bridges. SCDOT's objective was to have the project completed in the quickest amount of time possible. SCDOT appointed a committee to develop the documentation, solicit proposals and select a design-build contractor by committee review, rather than using the usual low bid process. The project consisted of designing and constructing a new bridge over the Enoree River on S.C. 418 in Laurens and Spartanburg counties and designing and constructing a new bridge over the Reedy River on Road S-316 in Greenville County.

Wateree River Bridge

This project involved replacing the entire existing 1,951-foot long by 44-foot wide bridge on U.S. 1/601 over the Wateree River. The team would complete the bridge and rehabilitate the decks, joints and bearings on the existing northbound lane bridge. The location of the project was a major fishing and recreational resource for the local community and the project also had to minimize disturbances to the Wateree River and flood plain. On February 4, 1999, United Contractors, Inc., the prime contractor of the project, received the prestigious Pinnacle Award for "Best Highway-Heavy Construction Project for 1998" from the Carolinas Associated General Contractors.

Honda Interchange

In early May 1997, Honda elected to build a major manufacturing plant in Florence County, South Carolina, and the South Carolina Department of Transportation agreed to build a new interchange to give the plant better access to I-95. The main issue was to complete the project in time for the plant's opening in July 1998, without sacrificing quality. The project consisted of relocating and widening 0.75 miles of a secondary road, constructing four interchange ramps, and a 300-ft. four-span bridge across I-95. A project like this would typically take several years to design, bid, and build. Since time was short, the state decided to use the design-build concept for the project.

Conway Bypass

The Conway Bypass Project consisted of the design and construction of a 28 mile, four to six lane highway in Horry County to take traffic from north Myrtle Beach to just south of Aynor.

Carolina Bays Parkway

The Carolina Bays Parkway project was a result of traffic congestion problems. Visitors to the beaches were getting caught up in traffic at bottlenecks on the way to the beach as well as traveling between points along the beach. The Carolina Bays Parkway project consists of a six to eight lane highway that runs north-south parallel to the beach. Approximately 40-miles long, the parkway begins at South Carolina Route 9 near the North Carolina border and extends to the Georgetown County line. The road runs parallel to the beach, on the mainland side of the intracoastal waterway.

1.3.2 BUILDING CONSTRUCTION

Background information of five design-build building construction projects performed by Hardaway Construction Corporation of Tennessee is outlined below.

Goodwill Industries of Middle Tennessee, Incorporated

The Goodwill Industries of Middle Tennessee project consisted of designing and constructing the new headquarters of Goodwill Industries. The 77,000 square-foot facility contains offices, warehouses, and a distribution center. The facility will serve as

a distribution and training center for handicapped and disabled individuals to prepare the handicapped to enter the workforce. The owners selected the design-build project delivery system because their main goal was to save money.

AAA Disposal of Tennessee, Incorporated

The AAA Disposal of Tennessee project involved the design and construction of a 10,500 square-foot facility. The facility consisted of offices and a shop facility. The owner selected the design-build project delivery system because this method offers single point responsibility.

Sumiden Wire Products Corporation

The Sumiden Wire Products project involved the design and construction of a 55,000 square-foot facility. The facility is used to store wire and process the wire into post-tension cables. The owner selected the design-build project delivery system for time and cost savings.

Stamtec Corporation

The Stamtec project involved the design and construction of a 64,000 square-foot industrial plant. The owner selected the design-build project delivery system for time and cost savings.

Energy Automation Systems, Incorporated

The Energy Automation project involved the design and construction of a 10,000 square-foot industrial plant. The owner selected the design-build project delivery system for time and cost savings.

CHAPTER TWO

LITERATURE REVIEW

Chapter Two describes the definitions, players, roles, and responsibilities of the main project delivery systems used in the United States. Related research concerning project delivery systems is also discussed in this chapter. A summarization of the work performed by other researchers in the industry is provided.

2.1 PROJECT DELIVERY SYSTEMS

Project delivery systems define the players, relationships, roles, and responsibilities of involved parties and the order of processes required to complete a project.

2.1.1 THE DESIGN-BUILD METHOD

Design-build is a project delivery system in which the owner contracts with a single entity to perform design and construction services under the provision of one contract. From a contractual perspective, design-build provides the owner with a single point of responsibility for design and construction services and guarantees the

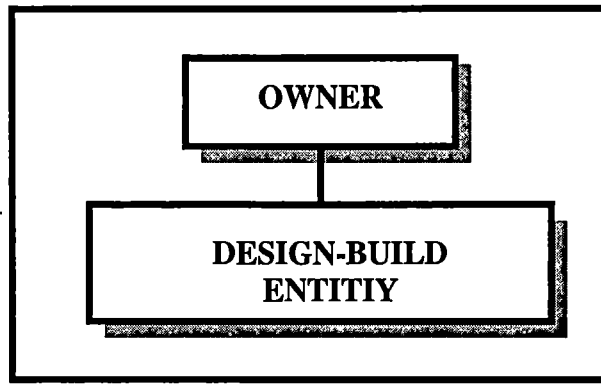


Figure 1. The Design-Build Team Relationship

performance of the finished product. The organizational structure of a design-build team is shown in Figure 1.

The owner has many responsibilities on a design-build project. These include providing preliminary site data such as site surveys, topographical information, and soil characteristics. The owner also works closely with the design-build team to develop a program that identifies the character, size, type, and functional relationships of the various features included in the project.

2.1.2 TYPES OF DESIGN-BUILD ENTITIES

There are four basic organizational forms in which design-build services are provided to owners. By identifying the primary contractor, or the party that contracts directly with the owner for design-build services, the type of design-build entity can be easily identified. The four types of basic arrangements are listed in Table 1 (2).

Table 1. Types of Design-Build Arrangements (2)

Type 1	Design Professional as Primary Contractor
Type 2	Contractor as Primary Contractor
Type 3	Design Professional-Contractor Joint Venture as Primary Contractor
Type 4	Design-Build Organization as Primary Contractor

According to a 1997 survey by Zweig White & Associates, 55% of design-build projects are constructor-led , 28% are led by an integrated design-build organization, 13% by design professionals, and 5% are joint ventures (3).

The Design Professional as Primary Contractor

In the first type of design-build arrangement, the owner has a direct contractual relationship with the design professional for all design and construction services required to complete the project. The design professional performs the design services and then contracts with a contractor to provide all construction services. This design-build arrangement accounts for 13% of design-build projects (3). Figure 2 shows the organizational structure of this type of team.

The design professional is responsible for the design if it does not conform to codes, professional standards, and any other requirements stated in the contract with the owner. They are typically responsible for ensuring that the project is constructed in a

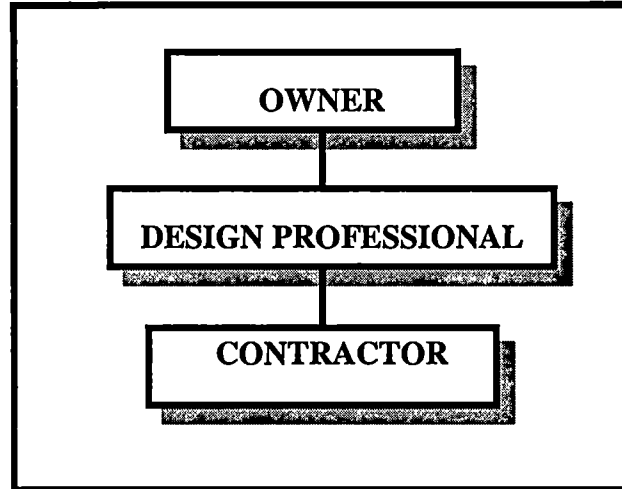


Figure 2. The Design Professional as Primary Contractor Relationship

workmanlike manner. The design professional is also responsible financially for costs that exceed the contract limit.

When the design professional is the primary contractor, the contractor does not have a contractual relationship with the owner to conform to the requirements of the contract documents. The contractor is not responsible to the owner for complying with applicable codes, laws, and regulations. The contractor is obligated to the design professional by virtue of the contractor-design professional contract.

The Contractor as Primary Contractor

The second type of design-build arrangement is the most common design-build configuration and accounts for 55% of design-build work (3). In this arrangement, the owner contracts directly with the contractor for design and construction services of a project. The contractor contracts with the design professional for design services. All construction services are provided to the owner according to the design professional's contract documents. Figure 3 shows the organizational structure of this type of typical team.

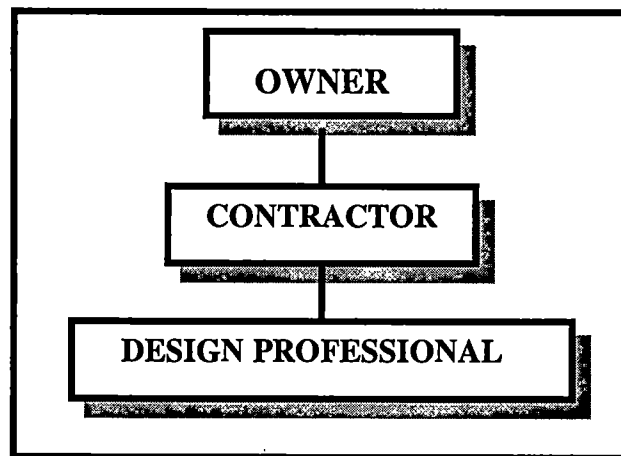


Figure 3. The Contractor as Primary Contractor Relationship

The design professional is responsible if the project's design fails to conform to applicable codes, standards of professional practice, and services noted in the agreement between the contractor and the design professional. The design professional is not

contractually responsible to the owner for any aspects of the design or construction of the project.

In some contracts, if the project exceeds the guaranteed maximum cost or contract amount, the design professional is typically responsible for redesigning the project without any additional cost to the contractor.

When the contractor is the primary contractor, the contractor is responsible for the design and construction of the project. This constitutes the contractor's responsibility to ensure that all design-related work complies with applicable codes, professional practice standards, and services established in the contract between the owner and contractor. The contractor is also responsible for constructing the project in a workmanlike fashion as indicated by industry standards, codes, and regulations.

The Joint Venture as Primary Contractor

In the third type of design-build arrangement, the joint venture is the primary contractor. This arrangement accounts for 5% of design-build projects (3). The design professional and contractor enter into a joint venture agreement in which they contract with the owner to perform all design and construction services of the project. Figure 4 shows the organizational structure of this design-build arrangement.

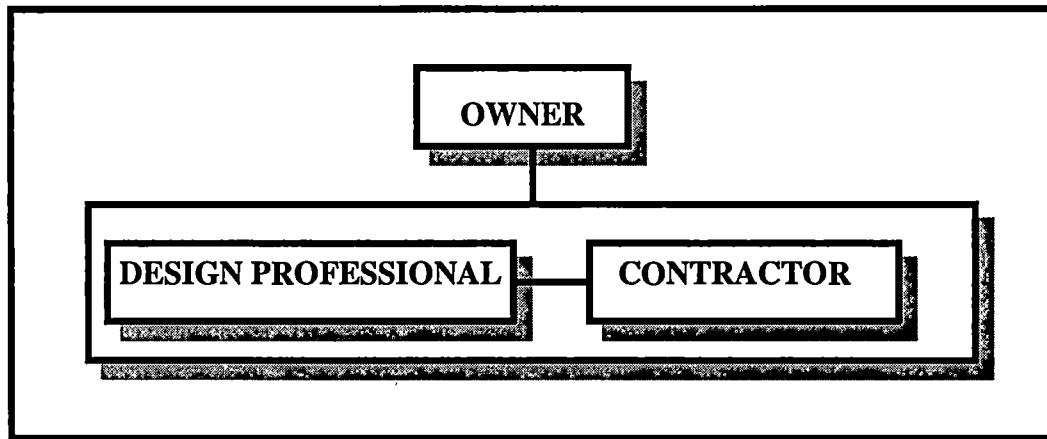


Figure 4. The Joint Venture as Primary Contractor Relationship

The agreement of the joint venture dictates the responsibility for the performance of these services to the involved parties. Many joint ventures have employees and run like a typical business. Some joint ventures are only contractual affiliations between several parties. These alliances often exist only in written form. There are many variations in the joint venture relationship depending on the capacity of the design professional and contractor, owner expectations, and economic factors. When the design professional or the contractor cannot adequately perform the required design and construction services, they may subcontract to other design professionals and subcontractors.

When the joint venture is the primary contractor, the design professional and contractor are contractually obligated to the owner for design and construction of the

project. These parties are responsible for any construction matters, and for ensuring that construction conforms to the construction requirements of the owner-joint venture contract.

The joint venture design-build team is characterized by the legal relationship between the design professional and the contractor. This relationship is considered to be similar to a partnership between parties and is governed by the same laws that preside over partnerships. A fundamental principle of partnership law is that each partner is responsible not only for its own acts and omissions, but also for the acts and omissions of the other partners. There is not a limitation to the extent of the responsibility of one partner to third parties for the acts and omissions of the other partners. Each partner is *jointly and severally liable* for the acts and omissions of its partners (2).

The design professional and the contractor may both be entitled to *indemnification* by the other if the act or omission was caused by wrongdoing of the other party. In the event that the contractor was found responsible based on *joint and several liability* for damages incurred by the owner due to an error caused by the design professional, the contractor could be entitled to reclaim the additional costs owed to the owner from the design professional (2).

The Design-Build Organization as Primary Contractor

In the last basic design-build arrangement, the design-build organization is a single entity. This arrangement accounts for 28% of design-build work (3). This entity provides design and construction services to the owner. This type of organization's staff consists of design professionals, construction managers, administrators, and a qualified labor force to perform all services to complete the project. Figure 5 shows a representation of this type of team.

The design-build organization is a legal entity that is independent of the owners of the organization. In this type of design-build organization, services cannot be subcontracted. The design-build organization is separate from the owners and does not have any members to subcontract services.

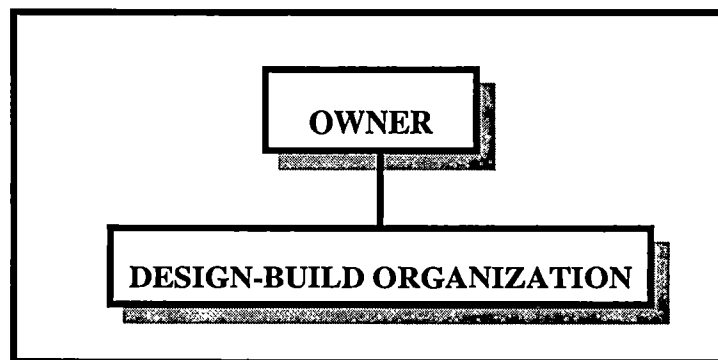


Figure 5. The Design-Build Organization as Primary Contractor Relationship

The design-build organization is responsible to the owner to ensure that the design of the project complies with codes, professional practice standards and requirements of the agreement between the design-build organization and the owner. The design-build organization is responsible for all aspects of construction and ensuring that the project conforms to construction practices and the construction provisions of the contract with the owner. The design professionals, contractors, consultants, and anyone acquired by the design-build organization are responsible to the design-build organization for their performance. There are not independent identities in this type of design-build arrangement. Legal responsibilities are not enforceable within the design-build organization. The design professional is responsible to the design-build organization only for design-related services and the contractor is responsible for the construction-related services.

2.1.3 OTHER PROJECT DELIVERY SYSTEMS

There are many variations of project delivery systems. The three most commonly used project delivery systems in the United States are design-bid-build, design-build, and construction management at risk. This section contains definitions of design-bid-build and construction management at risk to provide an understanding of the project delivery systems discussed in this thesis.

Design-Bid-Build

Design-bid-build is the traditional project delivery system used in the United States. In design-bid-build, the owner contracts separately with the design professional and contractor. The owner contracts with a design firm for design services. The owner solicits bids from contractors to perform construction services. A contractor is selected through the bidding process and enters into an agreement with the owner for construction services in compliance with the owner's contract documents (4). The sequential order of events establishes the terminology design-bid-build. The organizational structure of a design-bid-build team, which is commonly referred to as a tripartite relationship, is shown on Figure 6. The relationship between the owner, design professional, and contractor creates third-party obligations. Third-party obligations are not defined as parties in the standard contract. The relationship between the contractor and design professional is strictly of a third-party nature to the owner-contractor and owner-design professional agreements (4).

There are many variations to the design-bid-build project delivery system. The design professional might subcontract to design consultants. The contractor may also subcontract construction services to other contractors.

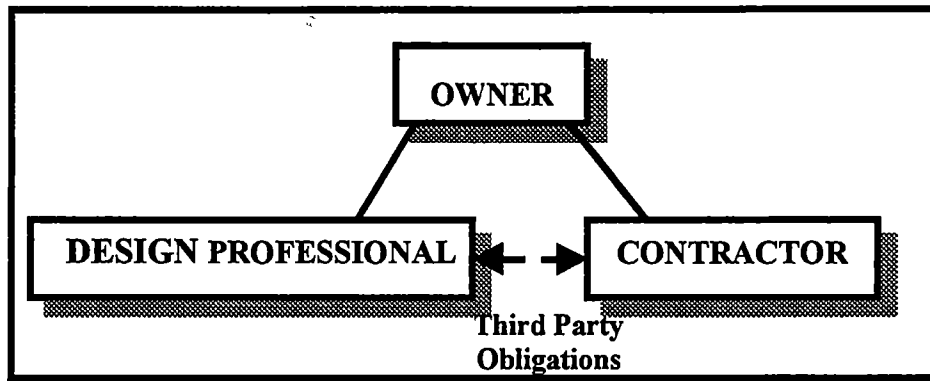


Figure 6. The Design-Bid-Build Tripartite Relationship

Construction Management at Risk

The construction management at risk project delivery system is when the owner contracts separately and concurrently with a design professional and a contractor. The owner contracts with a design organization for the design services of a project. The owner also contracts with a contractor for construction management and construction-related work that is in conjunction with the plans and specifications developed by the design professional. This type of delivery system allows the contractor to have input throughout the design phase of the project. The contractor can act as an independent consultant or the construction manager. Figure 7 shows a graphic representation of the organization of a construction management at risk team with the construction manager as an independent consultant or general contractor.

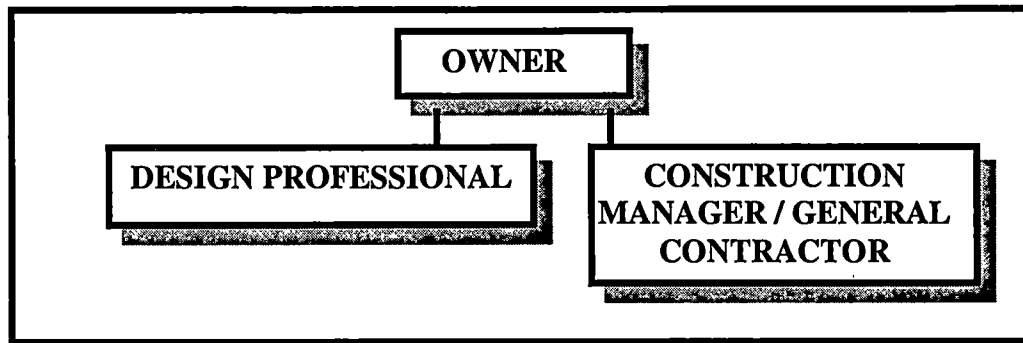


Figure 7. The Construction Management at Risk Relationship

2.2 RELATED STUDIES

Many aspects pertaining to the utilization of project delivery systems have been researched. Various case studies have investigated the success and failure, the advantages and disadvantages of project delivery systems and applications of procurement systems (5, 6). Several researchers have surveyed owners that often administer design and construction services. Those researchers have been successful in analyzing the owners' attitudes toward specific delivery methods (7, 8, 9). Some detailed case studies of industry builders and owners explain variations in the manner project delivery systems are administered both privately and in the public sector (10, 11).

The three main types of project delivery research conducted in the past are the impacts of management functions on project delivery, opinions on delivery system benefits, and empirical studies of project delivery systems.

2.2.1 MANAGEMENT EFFECTS ON PROJECT DELIVERY

Project management and planning strategies have been researched in several ways. The positive and negative effect of project outcome has been explored. One study examined and developed an approach to owner planning of the design-build contract management process for public sector agencies (12). The results of the study identified primary selection criteria specific to design-build. It also incorporated planning, analysis and areas that require decision-making by the owner.

A study at the University of Texas, Austin explored the relationships between the phases of pre-project planning and resulting costs and contract revision outcomes (11). The research analyzed projects completed within the University of Texas System. Incorporating eleven developed pre-planning criteria; the researchers analyzed the correlation between those criteria with project performance.

Another study investigated the impacts of information management on project success by using the engineer-procure-construct process model (13). By implementing activities within the model, a method was provided for predicting the impact of proposed information process changes on project cost and schedule performance.

The study indicated that information management practices could improve project performance. The research also identified a method to allow a project team to manipulate

activities in the engineer-procure-construct process and predict the effect the changes could have on the project schedule and cost.

These studies did not directly measure project performance, but they did provide an understanding of the factors that may be associated with good or poor project performance.

2.2.2 NON EMPIRICAL PROJECT DELIVERY RESEARCH

There has been research conducted to identify perspectives, opinions and feelings about project delivery systems. These studies offer reasons why owners select certain delivery systems.

One study quantifies an owner's confidence level that the choice to use one delivery method over another would produce improved project outcomes. This study compared design-bid-build and design-build. It analyzed types of owner organizations and types of projects for which design-build was more suitable. It also investigated project characteristics where design-build was the preferred method (9).

Another study surveyed the primary factors for selecting design-build for public sector organizations. The research showed that owners ranked characteristics, which they themselves control, as most critical such as: well defined scope, shared understanding of scope, owner sophistication, adequate owner staffing, established budget, and established

completion date. The research found that the criteria by which owners judge project successes are; satisfying the budget, the project conformation to the user's expectations, and completing the work within the schedule time limit. It was revealed that owners choose design-build to shorten duration, but judge its success more in terms of budget than schedule. (7).

Further research incorporated Molenaar's work and surveyed private and public sector owners to develop a better understanding of attitudes toward the top selection factors identified for selecting design-build (8). The research found that the primary reason design-build is selected is to take advantage of time savings inherent in the process.

2.2.3 EMPIRICAL PROJECT DELIVERY RESEARCH

A quantitative study was performed to identify factors known prior to the beginning of construction, which are warning signs of project cost and schedule growth (14). The study analyzed effects of various factors on project performance. The research also categorized cost and schedule growth throughout the construction phase.

Another study developed a method for measuring the effects of project integration on project performance. The results showed that each of the alternative methods of delivery possess higher degrees of team interaction than do traditional projects (1).

One study identified four critical project success factors. These factors are: selecting experienced team members, allowing teams to work together by using contracts that designate risk and reward in the appropriate proportions, developing team cohesiveness through shared goals and activities, and involving qualified parties early in the design phase to provide information to the team.

The University of Reading conducted a study that analyzed cost, schedule and quality data taken from design-build and design-bid-build projects built in the United Kingdom (15). The study identified three variations of design-build and compared them to design-bid-build projects using a management contracting approach. Of the United Kingdom projects analyzed, it was found that design-build projects resulted in an improvement in construction speed, delivery speed, a reduction in unit cost, more certainty in finishing on time, greater chance of finishing within budget, and a higher possibility of achieving specified quality.

CHAPTER THREE

SPEED OF DESIGN-BUILD PROJECTS

3.1 DELIVERY SPEED

The design-build project delivery system is often implemented to reduce the total delivery time of a project. The delivery time is the time period from the inception to the completion of a project. There are many reasons why design-build projects are completed in less time than other delivery systems, such as: reducing the extent of construction documents, collaborative decision making, reducing schedule delays, and eliminating the preparation of a bid package.

3.2 THE PROCUREMENT PROCESS

The bidding process used to procure design-build services is faster and easier for the owner than the competitive bidding method used to procure design-bid-build projects. In the traditional project delivery systems, projects are bid based on the plans and specifications developed by the design professional. In design-build, the team submits the design concept, which is less detailed than traditional projects, and the bid to the owner. The design-build procurement process requires fewer people and places the responsibility of the bid package from the owner and design professional to the design-

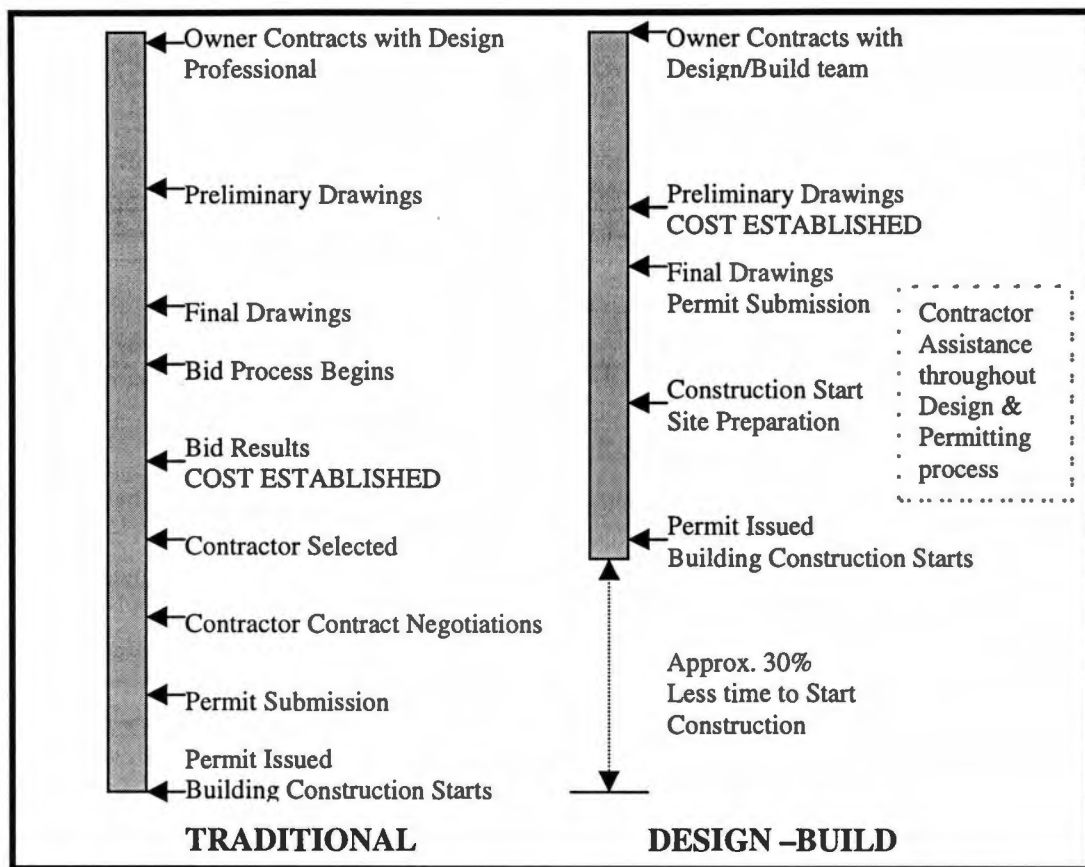


Figure 8. Comparison of the Procurement and Start up Process of Design-Bid-Build and Traditional Projects Methods

build team, which leads to a simpler bid package. By reducing the time to prepare the bid package, the procurement process will be simplified, and the time period before construction can begin is reduced by weeks or even months. Figure 8 shows a timeline comparison of the procurement process before construction can begin between design-build and design-bid-build projects.

As indicated in Figure 8, traditional delivery systems take on the average 30% longer to reach the construction phase.

The procurement method utilizes a prequalification process to allow the owner to evaluate the credentials of the design-build teams. The owner issues a Request for Qualifications (RFQ) to potential parties showing interest in the project that satisfy minimal qualifications. These parties are sought through public announcement for public projects, and often by invitation for private sector projects. The RFQ contains a general description of the parameters, professional requirements, and financial responsibilities of the project. When the qualification packages are submitted to the owner, usually three to five of the most qualified teams are shortlisted. The shortlisted teams then receive Request for Proposals (RFP). The RFP solicits design and cost proposals. A typical RFP contains project design criteria, site information, contract requirements, selection procedures and proposal requirements. A pre-proposal conference is held to allow proposers to ask questions and request clarifications pertaining to the RFP.

There are three methods owners can use to procure design-build services from prequalified teams: negotiation, bidding and design competition. In the negotiation process, the owner interviews the design-build teams to determine the team's interest, experience and qualifications. The teams are either selected from only qualifications or by comparison with other teams based on qualifications and preliminary design proposals.

In the bidding method, the owner selects the design-build team based on bids submitted by the design-build teams. Design-build bidding is similar to traditional

competitive bidding, except design-build owners require submittal of design concept drawings with cost proposals. The teams estimate the fee required for their services. Payment is proposed as a lump sum, cost plus, or a guaranteed maximum price.

In the design competition method, the owner selects the design-build team with the elite design. These design proposals are highly developed and complex. Owners usually depend on the help of an outside design consultant to assist in evaluating the design proposals. Owners often grant the design-build teams that are not selected a stipend to compensate for the time spent developing proposals.

3.3 CONSTRUCTION SPEED

The total construction time is the time period between the construction start date and the date of substantial completion. In the design-build method, design phases can be overlapped. This allows the contractor to begin construction earlier because they do not have to wait for all construction documents to be complete as in the traditional methods. In addition to overlapping design phases by fast-tracking the work, the design-build firm can modify the content of the design to permit construction to begin. For example, an experienced design-build team could simplify construction documents and begin construction on aspects of construction they are familiar with.

Teamwork and communication significantly affect construction speed. In design-build, the design professional and contractor come together to make decisions. Since designers and contractors work together throughout a project, decisions are made quickly. This allows for construction to begin sooner and for questions or problems to be resolved promptly without stopping construction.

3.4 CASE STUDY DATA & RESULTS

The following section analyzes the time to complete design-build highway and building construction projects. The South Carolina Department of Transportation and Hardaway Construction Corporation of Tennessee provided the following information.

3.4.1 HIGHWAY CONSTRUCTION

With the cooperation of the South Carolina Department of Transportation, five design-build highway projects were investigated. The total delivery time of the projects was documented. This was the time the contract was awarded between the owner and the design-build team to the time the project was completed. The total delivery time was documented for completing the project by the traditional design-bid-build method. The South Carolina Department of Transportation provided these values. These values were the original estimates by SCDOT for the design phase, bidding phase, and construction

phase. These values are presented in Table 2. Sample Calculations are located in the Appendix.

As indicated in Table 2, the average overall time saved by utilizing the design-build project delivery system was 47.7%. The initial design phase can add about one to two years to the life of a project. Special Experimental Project 14 and Sample Calculations in the Appendix, shows the breakdown, for the Wateree Bridge Replacement Project, of time to complete the project by the traditional design-bid-build method versus the estimated contract time for completing the project via design-build. The main reason for the time savings was because the design-build method eliminated the initial phases of design. Instead of developing a complete set of plans and specifications before the contractor was selected to complete construction, the contract documents were developed throughout the construction phase. Coordination amongst the design team allowed for earthwork and grading to begin early in the projects.

Table 2. Comparison of Time to Complete SCDOT Highway Construction via Design-Build vs. Design-Bid-Build Project Delivery Systems

Project	Design-Build Time (days)	Design-Bid-Build Time (days)*	Time Savings (days)	Time Savings %
Enoree & Reedy River Bridge Replacement	352	511	159	31.1
Wateree River Bridge Replacement	555	1207	652	54.0
Honda Interchange	304	900	596	66.2
Conway Bypass	1260	1990	730	36.7
Carolina Bays Parkway	900	1810	910	50.3
AVERAGE	674	1284	609	47.7

***Based on DOT engineer's estimates.**

The three complete projects were analyzed further. They were the Enoree and Wateree Bridge Replacement Projects and the Honda Interchange Project. The South Carolina Department of Transportation requires the contractor to submit an estimate breakdown of costs and quantities at the end of a project for final payment. With the cooperation of the SCDOT, areas of bridgework were determined. The bridge areas were divided by the time to complete the project in months to determine the delivery speed of the projects in units of square foot per month. Three similar bridge projects completed by the design-bid-build method were analyzed in the same fashion as the design-build projects and these values were compared. This comparison is shown in Table 3. Sample Calculations are in the Appendix.

Table 3. Comparison of Delivery Speed of SCDOT Bridge Construction via Design-Build vs. SCDOT Design-Bid-Build Bridge Construction Projects

Project	Design-Build Time (days)	Scope (SF)	Delivery Speed (SF/Month)
Enoree	352	31,820	2712
Wateree	555	85,844	4640
Honda	304	22,311	2202
		WEIGHTED AVERAGE	3468
Project	Design-Bid-Build Time (days)	Scope (SF)	Delivery Speed (SF/Month)
SC #32.967	1815	220,348	3642
SC #21.164	915	29,040	952
SC #12.606	1680	31,200	557
		WEIGHTED AVERAGE	1909
	INCREASE IN DELIVERY SPEED (%)=		81.67

As indicated in Table 3, the delivery speed in square foot per month of the three completed design-build projects had an 81.67% increase over the design-bid-build projects. The main reason for the delivery speed increases is attributed to the time saved from the elimination of the initial design phase.

3.4.2 BUILDING CONSTRUCTION

With the cooperation of Hardaway Construction Corporation of Tennessee, five design-build building projects were investigated. The total delivery time of the projects was documented. This was the time the contract was awarded between the owner and the design-build team to the time the project was completed. The total delivery time was documented for completing the project by the traditional design-bid-build method. Hardaway Construction Corporation of Tennessee provided these values. They were the estimates by HCCT and the design professional team members for the design phase, bidding phase, and construction phase. These values are presented in Table 4.

Table 4. Comparison of Time to Complete HCCT Building Construction via Design-Build vs. Design-Bid-Build Project Delivery Systems

Project	Design-Build Time (days)	Design-Bid-Build Time (days)*	Time Savings (days)	Time Savings %
Goodwill Industries of Middle Tennessee	365	390	25	6.4
Triple A Disposal of Tennessee	180	250	70	28.0
Sumiden Wire Products Corporation	365	425	60	14.1
Stamtec Corporation	270	330	60	18.2
Energy Automation Systems Incorporated	240	300	60	20.0
AVERAGE	284	349	55	17.3

***Based on a sample of 30 HCCT completed projects.**

As indicated in Table 4, the overall time savings was 17.3%. The savings in time are attributed to the early involvement of the contractor and the elimination of the initial design phase performed by a separate design professional. Most of these projects were pre-engineered buildings. HCCT reports that time is saved on these type of buildings with design-build because, the scope of work is determined early, the procurement time is reduced, and the design-build team is able to order the necessary materials for the facility much sooner than in the design-bid-build method. Earthwork and grading can begin early in the project. When the grading is complete and the materials arrive at the site, construction can begin.

3.5 SUMMARY OF RESULTS

The values for completing the selected highway and building construction projects show definite savings in time. These values do not represent all highway and building construction projects because only a sample of five projects of each type were analyzed. The analysis of delivery speed for design-build and design-bid-build projects also showed significant savings. These values do not represent all bridge construction projects. It is difficult to assess a true value for the delivery speed and compare that value to other projects because the conditions of every project are different. These values do show that time savings are inherent through the use of the design-build project delivery system. The main factors affecting time savings were the elimination of the initial design phase, the ability to fast-track the work.

CHAPTER FOUR

COST OF DESIGN-BUILD PROJECTS

An important factor in running a successful project is to ensure that costs are kept under control. Not only is staying within the budget crucial, but cost savings and increased profits are another sign of an efficiently executed project.

4.1 DECREASED PROJECT COSTS FOR THE OWNER

The design-build project delivery system allows the owner to decrease the total project delivery cost by reducing the project delivery time and design costs. Typically projects are financed while the cost of borrowing money increases per the time period it is borrowed. Projects are less costly when the construction phase can begin and be completed in a shorter time period. The reduction of project delivery time decreases the total project costs.

The design-build delivery system lets the owner know the cost of the work and the reasons behind the costs. This allows the owner to make informed decisions about features and options that may impact cost without impacting quality or utility. The designer can also make informed design decisions as contractor is aiding with actual cost input. This is important, since 75-85% of real savings occur before any construction takes place.

The owner can also save money by reducing design costs through the use of the design-build project delivery system. Design costs are reduced because the design professional can spend less time developing plans and drawings in the initial phases of the project.

4.2 INCREASED PROFITS FOR THE CONTRACTOR

In design-build, the contractor can increase total project profits by controlling the selection of construction materials and methods, reducing design and construction related activities, and responding quickly to unanticipated changes to the project.

Typically the fee a design professional charges for design services is minimal compared to the total project cost. A design-build team can increase profits by allowing the contractor to have more flexibility in the selection of construction materials. This permits the contractor to select the most cost-effective and reliable construction materials.

In the traditional project delivery systems, the contractor is not involved in the selection of construction materials. The contractor may not be able to determine the availability or price of an item in the bid package when the bid is prepared and may assume an alternate item is satisfactory. This can lead to problems throughout the project. Substitutions must be approved by the design professional before they are considered to be in compliance with the contract documents. Often the design

professional may choose to accept the contractor's substitutions. However, in design-build projects the contractor and design professional work together to determine the most valuable methods or materials in terms of cost and efficiency that meets the required performances of the project.

There are many construction-related processes the design professional and contractor perform that can be reduced through design-build. Preparing and documenting change orders in traditional delivery systems is very time consuming and confrontational. Design-build allows for this administrative process to be consolidated which reduces costs and increases profits to the contractor.

In a traditional project delivery system, the contractor must confer with the design professional before proceeding with construction when unforeseen circumstances arise. A design-build contractor can increase profits by responding immediately to unforeseen or altered factors of the project. The contractor can maintain the construction schedule to avoid disruption of the project. By reducing the hardships of unforeseen or altered factors on scheduled construction, the contractor can sustain contingency funds for profit at the end of the project.

4.3 INCREASED PROFITS FOR THE DESIGN PROFESSIONAL

In design-build, the design professional may increase profits because there are fewer problems resulting in the administrative construction process of change orders. This reduces costs and increases profits to the design professional.

The design professional may increase profits by spending less time in the development of the construction documents.

The agreement between the contractor and design professional is about quality. Design-build allows for the team to utilize value engineering to ensure total quality and maximize profits.

There are fewer contingencies in design-build projects resulting from budget overruns. The reduction in contingencies allows the design professional to increase profits.

A design-build design professional may increase profits by taking an equity interest in the project. By trading services for partial ownership of the complete project, the design professional benefits when the share increases in value over time. By assuming an equity interest in the project, the design-builder is investing in the project by the amount equal to the value of the design services. For this investment, the design-

build team is granted either an equity or ownership interest in the completed project, or higher fees for the balance of the project (2). When the design professional invests in the project, this also encourages quality of the project.

Design professionals may increase potential profit by improving their marketability. Design-build allows the design professional to provide prospective clients design and construction services instead of only design services. The design-build project delivery system also allows the design professional to enlarge their client base. When a contractor and design professional join to become a design-build team or firm, they bring their existing clientele. This endeavor increases the firm's marketability and expands their clientele.

4.4 CASE STUDY DATA & RESULTS

The following section analyzes the cost to complete design-build highway and building construction projects. The South Carolina Department of Transportation and Hardaway Construction Corporation of Tennessee provided the following information

4.4.1 HIGHWAY CONSTRUCTION

With the cooperation of the South Carolina Department of Transportation, the cost of the five design-build highway case studies was investigated. The total cost of the

projects was documented. This was the cost of the design and construction services. The total contract cost was documented for the case of completing the project by the traditional design-bid-build method. The South Carolina Department of Transportation provided these values. They were the original estimates by SCDOT for the design phase, bidding phase, and construction phase. These values are represented in Table 5. Sample Calculations are located in the Appendix.

As indicated in Table 5, the average cost savings was 9.2% by the utilization of the design-build project delivery system. The main reasons for these cost savings are shortened project duration, better coordination of the most efficient construction methods and materials, and reduced design costs.

Table 5. Comparison of Cost to Complete SCDOT Highway Construction via Design-Build vs. Design-Bid-Build Project Delivery Systems

Project	Design-Build Cost (\$)	Design-Bid-Build Cost (\$)*	Cost Savings (\$)	Cost Savings %
Enoree & Reedy River Bridge Replacement	2,863,040	3,032,000	168,960	5.6
Wateree River Bridge Replacement	7,890,700	9,162,000	1,271,300	13.9
Honda Interchange	7,962,000	8,875,000	913,000	10.3
Conway Bypass	386,000,000	404,142,000	18,142,000	4.5
Carolina Bays Parkway	232,000,000	263,320,000	31,320,000	11.9
AVERAGE	127,343,148	137,706,200	10,363,052	9.2

***Based on DOT engineer's estimate.**

The three complete projects were also analyzed for unit price savings. The breakdown of costs and quantities provided by the contractor and the areas of bridgework determined by SCDOT were used to determine the unit price to complete the design-build bridge projects. Three similar bridge projects completed by the design-bid-build method were analyzed in the same fashion as the design-build projects and these values were compared. This comparison is shown in Table 6. Sample Calculations are shown in the Appendix.

As indicated in Table 6, the difference in unit price from using the design-build for the selected SCDOT bridge projects versus the design-bid-build method was -6.7%. This value is negative, and indicates that the unit price of the selected design-build projects was more than the design-bid-build projects. It should be recognized that the average value of -6.7% was a weighted average. The weighted average was determined by dividing the total project amount for the three projects by the total square footage of the three projects. The size of the projects contributed to the negative value. These values do not represent the life-cycle costs and user costs. The average of the individual unit price savings was 2.7%.

Table 6. Comparison of Unit Price of SCDOT Bridge Construction via Design-Build vs. SCDOT Design-Bid-Build Bridge Construction Projects

Project	Design-Build Cost	Scope (SF)	Unit Price (\$/SF)
Enoree	\$2,863,040	31,820	\$89.98
Wateree	\$7,890,700	85,844	\$91.92
Honda	\$1,950,000	22,311	\$87.40
		WEIGHTED AVERAGE	\$90.76
Project	Design-Bid-Build Cost	Scope (SF)	Unit Price (\$/SF)
32.967	\$17,907,405	220,348	\$81.27
21.164	\$2,107,656	29,040	\$72.58
12.606	\$3,835,267	31,200	\$122.93
		WEIGHTED AVERAGE	\$85.00
	UNIT PRICE SAVINGS (%)=		-6.7

4.4.2 BUILDING CONSTRUCTION

With the cooperation of Hardaway Construction Corporation of Tennessee, the cost of the five building construction case studies was investigated. The total contract amount of the projects was documented. This was the total cost of design and construction services to complete the project. The total contract amount was documented for the case of completing the project by the traditional design-bid-build method. Hardaway Construction Corporation of Tennessee provided these values. They were the estimates by HCCT and the design professional members of the design-build team for the design of the work by the designer, letting the project out to bid, the contractor selection

Table 7. Comparison of Cost to Complete HCCT Building Construction via Design-Build vs. Design-Bid-Build Project Delivery Systems

Project	Design-Build Cost (\$)	Design-Bid-Build Cost (\$)*	Cost Savings (\$)	Cost Savings %
Goodwill Industries of Middle Tennessee	3,900,000	4,329,000	429,000	9.9
Triple A Disposal of Tennessee	1,100,000	1,378,300	278,300	20.2
Sumiden Wire Products Corporation	3,500,000	3,839,500	339,500	8.8
Stamtec Corporation	3,800,000	4,294,000	494,000	11.5
Energy Automation Systems Incorporated	1,100,000	1,347,500	247,500	18.4
AVERAGE	2,680,000	3,037,660	357,660	13.8

***Based on a sample of 30 HCCT completed projects.**

process, and the subsequent completion of the construction. These values are presented in Table 7.

As indicated in Table 7, the average cost savings from using the design-build project delivery system over the design-bid-build method was 13.8%. The savings in cost are attributed to the early involvement of the contractor, decreased project duration that led to reduced project costs, and the efficient coordination of construction methods and materials to optimize quality and value. Most of these projects were pre-engineered buildings. HCCT reports that costs are reduced on these type of buildings with design-build because the scope of work is determined early and the design-build team is able to work together to find the most cost effective materials. If the project were the traditional

design-bid-build project, the products specified in the contract documents could prevent the contractor having input pertaining to the selection of the most cost effective methods and materials.

4.5 SUMMARY OF RESULTS

The values for completing the selected highway and building construction projects show savings in cost. These values do not represent all highway and building construction projects because only a sample of five projects of each type were analyzed. The analysis of unit price for design-build and design-bid-build projects did not show savings. These values do not represent all bridge construction projects. It is difficult to assess a true value for the unit price and compare that value to other projects because the conditions of every project are different. These values did not show the life-cycle costs and user costs. The main factors affecting cost savings were the elimination of the initial design phase, the coordination of ordering materials early in the project and the ability to begin construction sooner.

CHAPTER FIVE

COMMUNICATION AND TEAMWORK OF DESIGN-BUILD PROJECTS

5.1 COMMITMENT

An important factor of any project is the commitment of the team members. A commitment is marked by: a strong desire to be a member of the team, willingness to exert high levels of effort, and a definite belief in and the acceptance of the values and goals shared by the team. Having shared goals and maintaining open and honest communication leads to becoming an effective team.

The design-build project delivery system organization allows for a strong commitment amongst team members. In design-build, the design professional and contractor join together at the beginning of a project. This permits the team to work together to derive a shared mission, vision, and goals early in the project.

5.2 COMMUNICATION AND TEAMWORK

Effective communication is critical for a successful project, especially between the design professional and the contractor. Interactive communication allows for task coordination, problem solving, information sharing, and conflict resolution. Construction documents are never perfect or complete. The design professional and contractor must

work together to resolve problems or issues in the design and interpret the scope of work during the construction of the project.

In traditional project delivery systems, the contractor and design professional have different interests and goals in the project. This often creates adversarial relationships between the two parties. In the design-build project delivery system, the design professional and contractor are closely linked and they have shared liability. Communication between them is more effective. This allows for the interests of the design professional and contractor to be synchronized. This creates a less competitive and combative relationship between the design professional and the contractor than in traditional project delivery systems.

In design-build projects, it is imperative from a financial and professional standpoint that communication problems with the contractor be reduced to an absolute minimum. The design professional is more likely to communicate with the contractor to achieve a clear understanding of the design. Collaborative decision making throughout the project allows for construction to begin sooner and to run more smoothly.

5.3 CASE STUDY INFORMATION

The South Carolina Department of Transportation and the design-build teams of the five selected design-build highway projects all reported positive responses to the

increase level of commitment, communication, and teamwork. Most of the projects were fast track and required extensive coordination amongst the design-build teams. A sense of early commitment was possible due to the interaction of the team members at the beginning of the project. The contractors and design professionals worked together as a team. All members of the teams contributed to the final project design. As the design for each project is developing, all of the members contribute to value-adding or cost-saving ideas. This allows for the team to incorporate the benefit of many years of valuable experience of both design and construction into each design. Multiple viewpoints or perspectives create richer output. By coordination and communication, the teams were able to plan and perform parts of the construction, while other parts of the process are being designed.

Hardaway Construction Corporation of Tennessee also reported positive comments to the levels of commitment, communication, and teamwork involved in design-build projects. On each of the projects there was a great level of communication amongst the design-build team. As a contractor, HCCT is familiar with the adversarial relationships that can develop on traditional design-bid-build projects. The design-build approach provides a single source of responsibility for the owner. The contractor and the design team work together as a team, allowing owners to spend their time and attention on the scope and needs of the project rather than mediating between the contractor and the design team. Communication gaps and misunderstandings are reduced because of the non-adversarial relationships within the design-build team. The improved

communication between the owner and the team also allowed for the projects to be executed in the most cost and value efficient manner.

CHAPTER SIX

INSURANCE AND BONDS FOR DESIGN-BUILD PROJECTS

Most construction projects require participants to be insured and bonded. Insurance and bonds provide protection against losses in the project for owners, contractors, and design professionals. Insurance and bonds also serve to allocate risk among the parties involved. Risk is usually allocated by evaluating the party most likely to reduce the risk of loss from happening, the party most likely to bear losses if they occur, and the party best able to spread the risk of loss to the other parties.

In the past, insurance and bonding companies have been structured to cater to traditional project delivery systems. As a result, design-build teams may have difficulty establishing adequate coverage because they are assuming different roles than they are accustomed. Design-build participants should obtain the advice of their insurance and legal advisors before entering into an agreement with the other team members.

6.1 TYPES OF INSURANCE

There are several types of insurance that can provide protection to owners, contractors, and design professionals. The four basic types of insurance coverage are

Workers' Compensation Insurance, Comprehensive General Liability Insurance, Property or Builder's Risk Insurance, and Professional Liability Insurance.

6.1.1 WORKER'S COMPENSATION INSURANCE

On construction projects, employers with a certain number of employees are required to carry Workers' Compensation Insurance. Workers' Compensation Insurance provides payments to employees who are injured while performing their jobs.

On design-bid-build projects, design-build projects with design professional as primary contractor, design-build projects with the contractor as the primary contractor, and design-build projects with the joint venture as the primary contractor, the design professional is the employer of the design personnel on their staff and the contractor is the employer of the construction personnel on their staff. The design professional and the contractor are not responsible for providing Workers' Compensation Insurance for the employees of the other party. On design-build projects, in which the design-build organization is the primary contractor, the design-build firm is the employer and is responsible for carrying Workers' Compensation Insurance for all of its employees.

6.1.2 COMPREHENSIVE GENERAL LIABILITY INSURANCE

Comprehensive General Liability Insurance includes several types of coverage that is specified to fit the requirements of the insured. It is designed to provide protection

to the owner and contractor for bodily injury and property damage. On traditional projects and design-build projects, the contractor acquires and pays for the insurance. When the design professional is the primary contractor and is assuming roles that the contractor typically performs, the design professional will obtain Comprehensive General Liability Insurance.

6.1.3 PROFESSIONAL LIABILITY INSURANCE

Design professionals usually carry Professional Liability Insurance for their main source of protection against liability. Professional Liability Insurance protects the design professional from damages and expenses from the negligent acts, errors, or omissions of the design professional. Professional Liability Insurance is written on a claims-made basis. This type of policy provides coverage per each claim and is limited to a monetary amount per policy year as defined in the insurance policy.

Professional Liability Insurance policies provide coverage for professional services of the design professional only. Owners and contractors cannot obtain Professional Liability Insurance, nor can they be named as an additional insured on the design professional's policy. On design-build projects where the contractor is responsible for providing design services to the owner, the contractor is not insured against errors or omissions by the design professional.

There are many limitations in Professional Liability Insurance policies. The type of design-build arrangement affects the exclusions and limitations of the policy. The design professional is most often affected by these exclusions when the design professional or the joint venture is the primary contractor, the design professional has a contractual agreement with the owner and is obligated to provide design and construction services. When the contractor is the primary contractor, the design professional is less affected by policy exclusions.

6.2 TYPES OF BONDS

A bond is a guarantee against failure to perform. In construction, bonds are obtained by the contractor to provide protection to the owner from the risks of default during construction. There are three types of bonds required for construction projects: bid bonds, performance bonds, and payment bonds.

6.2.1 BID BONDS

A bid bond or bid security guarantees that if a bid is accepted within the specified time, the bidder will enter into a formal agreement with the owner and will furnish the required construction performance and construction payment bonds. The purpose of the bid security is to compensate the owner for damages incurred if the selected qualified bidder does not accept the contract award (4).

6.2.2 PERFORMANCE BONDS

A performance bond guarantees that if the contractor defaults or fails to perform, the surety will either complete the contract, or provide sufficient funds up to the penal amount for such completion (4).

6.2.3 PAYMENT BONDS

Performance bonds obligate the bonding company to pay subcontractors, laborers, and material suppliers for their materials and services under the terms of the contractual agreement with the contractor, if the contractor defaults in payment responsibilities (4). Owners usually require a performance bond and payment bond equal to the contract amount.

When the design professional is the primary contractor, the design professional may have limited bonding capacity. A construction professional's bonding capacity is based on the amount of liquid assets held by the insured and the experience of the party. In this situation, the design professional has few assets in comparison to the size of required bonds. Often the design professional must depend on the bonding capacity of the contractor. If the design professional or the joint venture is the primary contractor, the contractor can provide a performance bond for the owner and sometimes for the design professional.

CHAPTER SEVEN

CAVEATS

While there are many benefits to using the design-build project deliver system, there are some disadvantages or areas where potential problems could occur. Part of this research involved interviewing South Carolina Department of Transportation, Hardaway Construction Corporation of Tennessee and each design-build team. These involved parties identified caveats for involved parties, that pertained to the use of design-build, based on the experience they have acquired from working on design-build projects.

7.1 CAVEATS FOR THE OWNER

One disadvantage to the owner using the design-build method is that the design professional does not act as the independent professional advisor to the owner. In the design-build arrangement, the design professional has a financial interest in the project. In the traditional tripartite relationship, the design professional is acting on behalf of the owner during the construction phase and the design professional could reject a portion of the contractor's work if it did not conform to the construction documents. The design professional was also responsible for approving the contractor's payment application and to act as an impartial initial arbitrator in disputes between the owner and the contractor. It is the recommendation of all interviewed design professionals and owners, that the

owner be cautious during the selection of the design-build team. It is essential that the owner select a team that is reputable and trustworthy. Owners that are uneasy could also hire an owner's design-build consultant to represent that owner throughout the design and construction process. This provides an independent professional that is responsible to the owner for general oversight, review, and approvals and replaces the design professional traditional role during construction.

Owners that do not have in-house personnel with expertise in preparing and administering design-build proposals and contracts have two options. The owner could hire an owner's design-build consultant to prepare the scope, definition, Request for Proposal documents, and to offer consulting services as needed. Or the owner could use direct selection or negotiation to bring the design-builder on board at the project inception to assist in establishing project goals, scope, and definition.

Owners should also be aware of the costs incurred to design-build teams to prepare a bid for Request for Proposal. On large projects, owners should shortlist no more than five teams. Teams that have repeatedly prepared proposals and were not awarded contracts were frustrated with the time and money lost. Some large public agencies offer a stipend for the teams not selected to compensate for their time and money spent preparing proposals.

7.2 CAVEATS FOR THE CONTRACTOR

The design-build contractor should be aware of some areas where potential problems could occur. These depend on the design-build arrangement, the needs of the owner and the project requirements.

Contractors and design professionals have separate legal concerns over the risk of liability associated with their professional roles. When a design-build team is formed, the attributes of the legal relationships between the owner, contractor, and design professional may change. This can subject one of the parties to additional risks of liability or prevent them from using specific liability defenses.

In traditional design-bid-build projects, contractors are liable only for performing the work in compliance with building practices and according to the information in the contract documents. Contractors are not normally responsible for the design professional's errors and omissions. In some design-build arrangements the contractor may be responsible to the owner for the design professional's errors and omissions. It is advised that the contractor thoroughly researches and understands the responsibilities and liabilities imposed on them by the contract and take all appropriate measures to meet those requirements.

It is possible to structure the relationships between the contractor and design professional in a way that each bears the risk of liability associated with its own activities. On the other hand, there is always a chance that in a lawsuit, the loss may exceed the ability of the negligent party to pay and the remaining costs could become the responsibility of the negligent party's team members.

Contractors should also be aware of the scope of their insurance coverage, because some gaps in insurance may exist. This can happen when contractors assume responsibilities beyond their traditional roles. Contractors and design professionals considering design-build projects should consult with a qualified professional advisor concerning the risks and liabilities associated with the various design-build arrangements. It is vital that each party understands how liability laws for design-build projects differ from those of traditionally structured projects to ensure that they can meet all applicable requirements to successfully partake in a project.

7.3 CAVEATS FOR THE DESIGN PROFESSIONAL

Design professionals who could potentially participate in a design-build project should be aware of areas where problems could occur. These depend on the design-build arrangement, the needs of the owner, and the project requirements.

In traditional design-bid-build projects, the design professional is usually liable only for their own acts and omissions. They are not responsible for the acts and omissions of the contractor. In some design-build arrangements, the design professional may be liable to the owner if the contractor fails to build in accordance with the requirements of the construction documents. In some cases, the design professional may not have adequate insurance to cover this additional risk.

Design professionals should be certain that there are no gaps in their insurance coverage. Some insurance companies cover the acts and omissions of the design professional only. Also, the contractor may be responsible for claims that the other party can not pay. Each party should require that the other party carry appropriate and adequate amounts of coverage and provide proof of coverage.

CHAPTER EIGHT

SUMMARY AND CONCLUSIONS

This chapter contains the main findings of this research. It also acknowledges the limitations of this research. Observations and lessons learned from this research are presented.

8.1 SUMMARY OF FINDINGS

This research used data from five design-build highway and building construction projects to compare design-bid-build and design-build. Highway and building construction projects were classified into separate categories.

The five South Carolina Department of Transportation design-build projects were analyzed to determine the average amount of time and cost savings. SCDOT estimated the time and cost to complete the design and construction of the design-build projects by the traditional design-bid-build method. There were time savings of 47.7% and cost savings of 9.2% from using the design-build method over the design-bid-build method.

The three completed South Carolina Department of Transportation design-build bridge projects and three design-bid-build projects were analyzed to determine the

average amount of delivery speed and unit price savings. Delivery speed was defined as the square footage of bridge completed per month of the total project time. The design-build projects had an 81.67% increase in delivery speed than the design-bid-build projects. Unit price was defined as the cost to complete the design and construction of the bridge per square foot of bridge. The weighted average of the design-build projects were 6.7% higher in unit price than the design-bid-build projects. The average based on individual unit prices of the design-build projects were 2.7% lower in unit price than the design-bid-build projects.

The time savings were attributed to the elimination of the initial design phase and the ability to coordinate construction throughout the project. Cost savings were also attributed to the elimination of the initial design phase. In construction, time is money, and by eliminating the initial design phase of one to two years, design-build will save money.

Five design-build projects completed by Hardaway Construction Corporation of Tennessee were analyzed for time and cost savings. The contractor and the design-build team members estimated the time and cost to complete the project by the design-bid-build method. The design-build method for those five projects had an estimated 17.3% time savings and a 13.8% cost savings over using the design-bid-build method.

The main reasons that the Hardaway Construction Corporation of Tennessee design-build projects saved time was because the initial design phase was eliminated and the construction work began earlier than typical design-bid-build projects. Materials were also ordered and delivered to the site much sooner than on design-bid-build projects to allow for building construction to begin. The cost savings were attributed to the ability to coordinate construction methods and materials with the design-build team to optimize quality and value.

The second part of the study identified certain aspects of design-build projects such as communication, teamwork, insurance, bonding and caveats. The South Carolina Department of Transportation design-build teams and the Hardaway Construction Corporation design-build teams reported that there was a higher level of communication and teamwork involved in the design-build projects than on design-bid-build projects.

One of the caveats for owners was the absence of the design professional as the independent professional advisor. It is advised that owners select a design-build team that is trustworthy and reputable. Owners that lack the knowledge to develop the project requirements and prepare Requests for Proposals should obtain a consultant to assist in effectively completing these tasks.

Caveats for contractors and design professionals include legal concerns and insurance coverage. In design-build the contractor and design professional assume

different responsibilities than on design-bid-build projects. Contractors and design professionals are advised to consult with a qualified professional advisor concerning the risks and liabilities associated with design-build. Each party should ensure that they have adequate insurance and bonding coverage. They should also understand how liability laws for design-build projects differ from design-bid-build projects to ensure that they can meet all applicable requirements to successfully partake in their projects.

8.2 LIMITATIONS OF RESEARCH

It should be noted that the values for cost and time savings were based on a sample of five highway and five building construction projects. The values for the design-bid-build cost and time for project completion were estimated values. The South Carolina Department of Transportation, Hardaway Construction Corporation of Tennessee, contractors and design professionals of the design-build teams performed the estimations.

The values for delivery speed and unit price for The South Carolina Department of Transportation design-build and design-bid-build projects were compared. It should be recognized that the size of the project has a significant effect on delivery speed and unit price. Each project had different parameters and conditions and those could affect the values for unit price and delivery speed.

8.3 FUTURE RESEARCH

This study proved that cost and time savings are likely with design-build. This study investigated a limited number of projects. Within the next five years The South Carolina Department of Transportation will complete the Conway Bypass and the Carolina Bays Parkway projects. The contract amount for these two projects are \$386,000,000 and \$232,000,000. These projects are some of the largest highway design-build projects in the state of South Carolina. A study of these projects will provide the highway construction industry with information about the design-build project delivery system.

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APPENDIX

SAMPLE CALCULATIONS

1. Breakdown of SCDOT Wateree Project Time Estimates (From Table 2)

*Based on SCDOT Engineer's Estimate

SCDOT Traditional Design-Bid-Build Method Contract Time Estimate*:

Design and Plan Preparation	180 days
Advertise, Bid and Award Contract	60 days
Construction Time	<u>967 days</u>
Total Project Time	1207 days

Design-Build Method Contract Time:

Design, Plan Preparation, and Construction Time	452 days
Review, Select and Execute Contract	<u>103 days</u>
Total Project Time	555 days

$$\text{Time Savings} = 1207 - 555 = \boxed{652 \text{ days}}$$

$$\text{Time Savings \%} = (1207 - 652) / 1207 * 100 = \boxed{54.0\%}$$

2. Sample Calculations of Delivery Speed (From Table 3)

*Based on SCDOT Contracts

$$\text{Delivery Speed} = (\text{Scope in SF}) / (\text{Time in days} / 30)$$

$$\text{SCDOT Wateree Project Delivery Speed} = (85,844 \text{ SF} / (555 \text{ days} / (30 \text{ days/month}))) = \boxed{4640 \text{ SF/Month}}$$

$$\text{Weighted Average of Design-Build Delivery Speed} =$$

$$(\text{Sum of Scope} / \text{Sum of Design-Build Time}) = (31,820 + 85,844 + 22,311) / ((352 + 555 + 304) / 30) = \boxed{3468 \text{ SF/Month}}$$

$$\text{Weighted Average of Design-Bid-Build Delivery Speed} =$$

$$(\text{Sum of Scope} / \text{Sum of Design-Bid-Build Time}) = (220,348 + 29040 + 31,200) / ((1815 + 915 + 1680) / 30) = \boxed{1909 \text{ SF/Month}}$$

$$\text{Increase in Delivery Speed} = (3468 - 1909) / 1909 * 100 = \boxed{81.67 \%}$$

3. Sample Calculations of Cost Estimates (From Table 5)

*Based on SCDOT Engineer's Estimate

SCDOT Traditional Design-Bid-Build Method Cost Estimate*:

Preliminary Engineering	\$525,000
Construction	\$7,852,000
Construction Engineering and Contingencies	<u>\$785,000</u>
Total Project Cost	\$9,162,000

Design-Build Method Cost Estimate:

Preliminary Engineering (SCDOT)	\$20,000
Design, Construction and Construction Engineering	\$7,845,700
Construction Monitoring (SCDOT)	<u>\$25,000</u>
Total Project Cost	\$7,890,700

$$\text{Cost Savings} = (9,162,000 - 7,890,700) = \boxed{\$1,271,300}$$

$$\text{Cost Savings \%} = ((9,162,000 - 7,890,700) / 9,162,000) * 100 = \boxed{13.9\%}$$

4. Sample Calculations of Unit Price (From Table 6)

*Based on SCDOT Contracts

Unit Price = (Contract Amount)/(Scope in SF)

SCDOT Wateree Project Unit Price =

$$(\$7,890,700 / 85,844 \text{ SF}) = \boxed{91.92 \text{ \$/SF}}$$

Weighted Average of Design-Build Unit Price =

(Sum of Design-Build Cost/ Sum of Design-Build Scope in SF) =

$$(2,863,040 + 7,890,700 + 1,950,000) / (31,820 + 85,844 + 22,311) = \boxed{90.76 \text{ \$/SF}}$$

Weighted Average of Design-Bid-Build Unit Price =

(Sum of Design-Build Cost/ Sum of Design-Build Scope in SF) =

$$(17,907,405 + 2,107,656 + 3,835,267) / (220,348 + 29,040 + 31,200) = \boxed{85.00 \text{ \$/SF}}$$

$$\% \text{ Difference in Unit Price} = (85.00 - 90.76) / 90.76 * 100 = \boxed{-6.7 \%}$$

South Carolina Department of Transportation

**Initial Report
For
SEP (Special Experimental Project) 14**

**Design-Build Contract
for
the Replacement of the
US 1/601 Southbound Bridge Over the Wateree River
Kershaw County, South Carolina
SCDOT File # 28.709**

August 14, 1997

**Initial Report For SEP (Special Experimental Project) 14
Design-Build Project for the Replacement of the US 1/601 Southbound Bridge Over
the Wateree River in Kershaw County, File No. 28.709 (PIN 18062)**

A. INTRODUCTION

The South Carolina Department of Transportation (SCDOT) submits this initial report under the provisions of Special Experimental Project No. 14 (SEP 14) for the use of innovative contracting practices.

A committee was appointed to develop the necessary documentation, solicit proposals, and select a design-build contractor. A design-build contract has been executed for the replacement of the US 1/601 Southbound Bridge Over the Wateree River located near Camden, Kershaw County. This initial report includes a brief scope of the design-build project, a brief history of the contracting process, effects on the bids received, estimates of cost and time savings, lessons learned thus far, and industry reaction to the process.

B. SCOPE

The scope of work for this project includes the design and construction of the bridge identified in the Introduction above. The design work includes the required surveys, geotechnical work, hydraulic analyses, scour analyses, and superstructure and substructure design including seismic analyses. The design will meet the requirements of SCDOT Design Memorandums and AASHTO Standard Specifications for the Design of Highway Bridges, Sixteenth Edition, 1996 and subsequent Interim Specifications.

Construction includes the removal and disposal of the existing bridge structure along with any accumulated debris, all necessary foundation work, substructure work, superstructure work, excavation, roadway approach work, and erosion and sediment control work items. Construction engineering, including quality control is the responsibility of the Contractor. SCDOT has the right to review design plans and construction activities including making independent tests of materials.

C. HISTORY

SCDOT advertised for the replacement of this bridge through a Request For Proposals (RFP). SCDOT provided the RFP to all interested parties at no cost. An information package including design memoranda, special provisions, project scope, location plan of the bridge, and existing bridge plans was provided for a fee of \$600. As part of the proposal, each contractor submitted a preliminary plan of the bridge. The preliminary plans showed plan and elevation views of the bridge including the span arrangements, typical sections through the superstructure, and elevations of the proposed

substructure units. The contractors' proposals also contained the time required to complete the project and restore traffic to the bridge as well as the cost of the project. Their proposals required two parts, a Technical Proposal and a Cost Proposal. The Technical Proposal consisted of design and construction, management, and project schedule. The Cost Proposal consisted of the proposed cost of the bridge by phases: Insurance and Bonds; Design; Mobilization; Removal and Disposal of Existing Bridge; Substructure Construction; Superstructure Construction; Roadway Approach Construction; Traffic Control; QC/QA including Testing and Inspection; Warranty (Five Years: Bridge Deck Joints and Bearings); and Total Project Cost. An Owner's Contingency Fund in the amount of \$300,000 was established. The maximum Project Cost is the sum of the proposed cost plus the \$300,000 from the Owner's Contingency Fund.

All Technical Proposals were evaluated prior to opening the Cost Proposals. The Technical Proposals were scored first. This score was based upon technical design, experience and qualifications of the Proposer including the Design Engineer and major subcontractors, and the time of completion. The Proposer could have been requested to make an oral presentation of their Technical Proposal and answer any questions the SCDOT may have with respect to the Technical Proposal before the Technical Proposal is scored. However, the Committee did not use this option.

Technical scores were based on a scale of 0 to 100. The relative weight of each criteria was set based upon the individual project requirements. The following criteria was considered in determining the Technical Score:

1. Technical Criteria Plan Evaluation

a. Innovation of Design/Constructability

b. Future Maintenance

Maximum Score:

20

2. Management Criteria

a. Quality Control Plan

b. Demonstration of Ability to Perform Work

c. Applicable Experience of Team

d. Management Approach

e. Financial Condition

Maximum Score:

45

3. Project Schedule

a. Time duration of traffic detour (24 months maximum)

b. Project completion time (27 months maximum)

Note: Schedules exceeding the maximums given in a. or b. are considered non-responsive.

Maximum Score:

35

Initially, a Technical Proposal receiving a score from the Selection Committee of less than 75 points was not to be considered for further evaluation. However, the Committee changed this score to 70 as the minimum. After the Technical Proposal score was calculated, the Project costs were reviewed. The Selection Committee did make adjustments in the proposed Total Project Cost based on waiver of the Owner's Contingency. A Composite Score was calculated as follows:

$$\text{Composite Score} = \frac{\text{Total Project Cost}}{\text{Technical Score}}$$

The Selection Committee prepared and made a recommendation to the SCDOT Executive Director to start negotiations based on the order of Composite Scores of the Proposers.

The SCDOT Executive Director approved the order of negotiations and immediately the SCDOT offered to start contract negotiations to the Proposer with the lowest Composite Score. However, if the parties were unable to execute a contract, the SCDOT could offer the contract to the Proposer with the next lowest Composite Score. This was not necessary since successful negotiations produced a contract with the first Proposer.

A brief outline of the project milestones is given below:

Advertise RFP

February 6, 1997

Pre-proposal Meeting
SCDOT Headquarters Building
Fifth Floor Auditorium
955 Park Street
Columbia, SC 29201

February 28, 1997
10:00 AM

Deadline for SCDOT to receive questions
in writing.

March 7, 1997
12:00 Noon

Deadline for SCDOT to mail response to
written questions

March 14, 1997

Submittal of eight (8) copies of Proposals

March 26, 1997
12:00 Noon

Recommendation to SCDOT Director

April 11, 1997

D. BIDS RECEIVED

Six (6) contractors submitted proposals for this project. The number of proposals received was considered close to the same number of bids which would have been anticipated using the traditional design-bid-build contracting method. The costs proposed for the work ranged from a high of \$17,720,000 to a low of \$7,856,000. The completion times proposed ranged from a high of 821 days to a low of 457 days. The tabulation below shows the cost and time for each proposal submitted. The time required for the duration of the detour is shown separate since this was identified as a priority.

Proposer	Cost	Time Detour	Time Completion
1	\$ 7,856,000	388	457
2	\$ 8,499,000	305	550
3	\$ 8,115,000	675	730
4	\$17,720,000	234	821
5	*		
6	*		

* Did not meet minimum technical score

E. TIME AND COST SAVING

Time The Design-Build method of contracting appears to have saved significant time when compared to the time estimated for the traditional design-bid-build method of contracting. The time savings will be more accurately determined at the end of the project when the actual construction time will be known. The estimates of time shown below for both the Design-Build and the traditional design-bid-build methods of contracting show a time savings of 647 days, approximately 53.6 % of the time required for the traditional method.

SCDOT Traditional Design-Bid-Build Method Time Estimate:

Design and Plan Preparation	180 days
Advertise, Bid and Award Construction Contract	60 days
Construction Time	967 days
Total Project Time	1207 days

Design-Build Method Contract Time:

Design, Plan Preparation, and Construction Time	457 days
Review, Select and Execute Contract	103 days
Total Project Time	560 days

Time Savings	647 days
---------------------	-----------------

Cost While the proposals varied widely, the cost proposed by the selected contractor represents a substantial saving when compared to the estimated cost of the project using the traditional design-bid-build method of contracting. The cost savings can be determined more accurately at the end of the project at which time the actual construction cost will be known. The savings is estimated to be at least \$1,261,000 or 13.8% of the cost required using the traditional method.

SCDOT Traditional Design-Bid-Build Method Cost Estimate:

Preliminary Engineering	\$ 525,000
Construction	\$7,852,000
Construction Engineering and Contingencies(10%)	\$ 785,000
Total Project Cost	\$9,162,000

Design/Build Method Cost Estimate :

Preliminary Engineering(SCDOT)	\$ 20,000
Design,Construction,and Construction Engineering	\$7,856,000
Construction Monitoring (SCDOT)	\$ 25,000
Cost Sharing Provision of Contingency Fund	\$ 0
Total Project Cost	\$7,901,000
Cost Saving	\$1,261,000



Office of the Executive Director
(803) 737-1314 • Fax (803) 737-2038

LESSONS LEARNED

South Carolina Department of Transportation

State Highway Engineer
(803) 737-1314 • Fax (803) 737-2038

Since this is the second Design-Build project that the SCDOT has performed, the Department has taken into consideration the lessons learned from the first Design-Build project. This knowledge and insight of another similar Design-Build project was particularly valuable. The Committee was very satisfied with the requirement that the Proposers submit a separate Technical Proposal to evaluate before looking at the Cost Proposal. We are certain that new lessons will be apparent during the course of the project and cannot be fully evaluated until the project is complete.

G. INDUSTRY REACTION

Interest in the Design-Build project has been strong. Forty(40) firms requested the RFP, twelve(12) firms purchased the information package, forty four(44) individuals representing contractors and designers attended the pre-proposal meeting, and six(6) firms submitted proposals.

The reactions of both the construction and design industries have been mixed as were the first Design-Build project. While there has been a high degree of interest in this project from the construction industry, there is a concern among contractors as to the Design-Build method becoming the standard method of contracting. Their concerns also include 1) the additional work required to prepare a proposal, 2) the risk of not having definite plans and quantities at the time of bid, 3) the added responsibility of construction management including quality control, and 4) the inclusion of the committee's judgment of the relative qualifications of the contractors in the selection process. The selected contractor has been very supportive of the contract development process and has eagerly anticipated the start of construction. The contractor demonstrated his confidence in this project by beginning design work and permit acquisition at his risk prior to execution of the contract. Reaction from the design industry has generally been positive. Many firms see this as an opportunity that may not have otherwise been available to provide engineering services for a transportation project. Concerns expressed by designers are 1) competition among design firms is limited to the number of contractors interested in the project, 2) the design firm is a subcontractor and thus must try to please the contractor and the DOT while maintaining high engineering standards, 3) the major cost of preparing a proposal falls to the designer in the form of engineering and plan preparation, and 4) the designers reputation is linked to the contractor's performance and in the case of poor performance, could jeopardize the designer's future ability to compete for work with the DOT.

H. SUMMARY

The use of the Design-Build contracting method has accomplished the purposes stated in the Work Plan of producing a savings in time and cost for the replacement of the bridge over Wateree River, and allowing SCDOT to explore this innovative contracting method. While our initial opinion is that the Design-Build contracting method has been successful for this project, some aspects of this project cannot be fully evaluated until the project is completed. The lessons learned in this project will prove valuable and directly applicable to future Design-Build projects in South Carolina.

VITA

Melinda Dawn Carlisle was born in Nashville, Tennessee on January 2, 1976. She attended schools in the public system of Hendersonville, TN, the Sumner County School System, where she graduated from Beech Senior High School in May 1994. She entered The University of Tennessee, Knoxville during August of 1994 where in December, 1998 she received the Bachelor of Science in Civil Engineering. She also received the Engineer Intern certification for the State of Tennessee in December 1998. Throughout her undergraduate career, she interned at several engineering firms in Nashville, TN. She then entered the Master's program in Civil Engineering with a concentration in Construction at The University of Tennessee, Knoxville in January of 1999. While working on her graduate degree, she worked at an engineering and construction company. She received the Master of Science degree in December 1999. She plans to work for an engineering firm in the Nashville, Tennessee area.