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The Master Builder project delivery system and designer construction knowledge

Leslie C. Battersby
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THE MASTER BUILDER PROJECT DELIVERY SYSTEM AND DESIGNER CONSTRUCTION KNOWLEDGE

A Thesis
Presented to
The Faculty of the Department of
Civil and Environmental Engineering
San Jose State University

In Partial Fulfillment
Of the Requirements for the Degree
Master of Science

By

Leslie C. Battersby

December 2000

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ABSTRACT

The Master Builder Project Delivery System
And Designer Construction Knowledge
by Leslie C. Battersby

During the early part of the Twentieth Century, the Master Builder system was the dominant project delivery system used in the construction industry. Unfortunately, the system no longer exists as many different fragmented systems for project delivery have replaced Master Builders. The demise of the Master Builder has contributed to difficulties in managing projects in the construction industry. This research provided a review of the history of the construction industry, project delivery systems, constructability, and a discussion on construction industry fragmentation. The research also included conducting a survey of construction industry professionals on the current processes they were using for training designers. The results obtained from the survey and analyses of the results are included in this document. Finally, the research showed how the demise of the Master Builder project delivery system, and the rise of the numerous fragmented delivery systems, has led to a reduction in designer construction knowledge.

Dedication

To Dad the best Civil Engineer I know

Luck is the residue of good design
Branch Rickey, General Manager
Brooklyn Dodgers

Acknowledgements

The author wishes to acknowledge his family, in particular his wife Debbie and his son Charlie. This work has been possible because of their support, understanding and love. It is equally important to recognize the role of the author's parents, L. Charles and Brenda Battersby; they have continually supported the author's educational pursuits and provided much love throughout his life.

The author also acknowledges the educators who have been instrumental in this research and the author's education. The author extends the sincerest gratitude and thanks to Dr. Janet K. Yates. Dr. Yates has shown the utmost patience, kindness and inspiration to the author. Additionally, Dr. Yates has provided creativity, insight and sincere interest in this research. The author wishes to also extend sincere gratitude to Dr. Thomas Schultz. Dr. Schultz provided the author with guidance and mentoring during his undergraduate work and encouraged the author to return to graduate school many years later. The author extends his sincere gratitude to Mr. David Chisholm for finding the time in a busy schedule to participate as a committee member. Special gratitude is extended to the faculty of the Civil and Environmental Engineering Department at San Jose State University.

Lastly, the author extends sincere gratitude to the numerous industry professionals that participated in this research. The author extends sincerest thanks to those industry professionals that have provided support and understanding for this research. Particularly, the author wishes to extend the deepest gratitude and thanks to Mr. Michael J. Blach of Blach Construction Company for his personal and financial support of the author's educational pursuits. The author also extends his gratitude to Mr. Robert Hauck, Mr.

Richard Kramer, Mr. Gregory KleinSmid, Mr. Paul Kehoe and Mr. Tom Ross of Blach Construction Company for their countless reviews, levity and comments that made this research project better. Special thanks and gratitude to Mr. Tom Kobayashi for assisting with, and solving numerous, software problems related to this project. Finally, the author extends his sincere gratitude to all the other employees at Blach Construction Company who watched the "store" and took care of the details while the author was preoccupied with this research.

So many understanding, supportive individuals and corporations have truly blessed the author, this research project would not have been possible without them.

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LIST OF ABBREVATIONS

A/E/C – Architecture Engineering and Construction

AGC – Associated General Contractors

AIA – American Institute of Architects

AIACC – American Institute of Architects California Council

ASCE – American Society of Civil Engineers

CII – Construction Industry Institute

DEFINITIONS

Construction Manager – An individual or firm that performs construction management for owners of construction projects.

Contractor – A firm or individual that is licensed to perform construction work.

Design/Build – A construction project delivery system that construction project owners use to procure both design and construction services form one entity.

Designer – Firm or person legally practicing in the professions of architecture or engineering.

Master Builder – An individual that was historically performing both design and construction of a new building or other construction project.

Non-Designer – Firm or person practicing in other professions other than architecture or engineering.

Owner/Property Manager – A firm or individual that either owns a property or is actively involved with its construction, management and maintenance.

Registered or Licensed Professional – An individual that is legally licensed, typically by the state, to practice the professions of architecture or engineering.

RSQ – A statistical function that indicates the level of shared variance.

r-value – A statistical function indicating correlation between two arrays or results.

CHAPTER 1 INTRODUCTION AND BACKGROUND INFORMATION

INTRODUCTION

The construction industry has different types of problems and most of them are related to the design process and the management of projects. Excessive amounts of manpower and money have been invested in trying to determine solutions to the problems that arise during construction processes. Constructability, different types of project delivery systems, and construction management are areas that have received the most attention in recent years. Incorporation of constructability reviews into the early design stage of projects may produce better project results. The results of several research investigations indicated that contractors and construction managers should provide constructability information during the design of a project (ASCE 1986, CII 1986, ASCE 1991, Fischer and Tatum 1997, Gibson, et al 1995 and Hanlon and Sanvido 1995).

Currently, there is minimal research into the impact that changes in delivery systems, or designer construction knowledge, have had on the U.S. construction industry. This research provides background information on the different types of project delivery systems, the impact of changing project delivery systems, a brief synopsis of the history of the construction industry, constructability, and problems with A/E/C industry fragmentation. The background information provided demonstrates how changes in the industry have affected the ability of designers to obtain appropriate construction knowledge. The research also generated recommendations for a Master Builder project delivery system that may produce improved project results.

This thesis presents background information on project delivery systems, the research scope, research methodology, research objective and purpose, constructability reviews, and construction management methods. It presents how the research was conducted; project participants, how the data was analyzed and how the results can be used by personnel in the construction industry to establish guidelines to improve designer construction knowledge and modify current project delivery systems.

BACKGROUND INFORMATION

Designer Construction Knowledge

This research is the first phase of a project on designer construction knowledge. A substantial amount of research has been dedicated to constructability, construction project delivery systems, construction industry fragmentation and the influence of cost on construction. However, only a small amount of research has been dedicated to the quantification of the knowledge designer's possess about construction methods and techniques and the importance of this on the success, or failure, of a project.

Only a small portion of the contemporary construction research addresses the shift from designer controlled projects to projects controlled by other industry professionals. Most existing research deals with the contractor providing construction knowledge rather than the project designers. Based on previous research, it appears that the construction industry has progressed from a system of Master Builders in the Nineteenth Century to a fragmented industry in the Twentieth Century that is comprised of designers, owners, construction managers and contractors. Additionally, construction industry fragmentation has led to the exclusion of designers from construction processes and this has led to a reduction in their construction knowledge, along with increased construction costs and delays.

RESEARCH SCOPE

The scope of this research project included the following areas:

Designer Construction Knowledge

The degree of construction knowledge designers possess was investigated and a survey of construction industry professionals was used to establish designer knowledge of construction practices, and the implementation of these practices during the design phase of projects. The survey was also used to identify the ways in which architects and engineers are implementing their construction knowledge and how new industry design professionals are being trained relative to construction techniques and methods.

Historical Review

A historical review of the construction industry was conducted that included information from the early "Master Builder" eras during the 1800s to the Architectectural/Egineering/Construction (A/E/C) processes that were used in the next decades. This review is provided as background information on the construction industry.

Project Delivery Systems

The section on project delivery systems compares and contrasts the "Master Builder" system with current construction management practices. The differences in practices that were identified were used to develop recommendations on how to improve the knowledge of designers on construction methods and increase the use of constructability reviews. Several different project delivery systems are discussed in this thesis, including Design/Bid/Build, Construction Management, and the Design/Build method.

Constructability

A review of research related to the concept of constructability is discussed and the results from prior research on constructability reviews are presented to demonstrate their level of implementation in the construction industry and how they affect designer construction knowledge.

Industry Fragmentation

Fragmentation of the construction industry is another factor that affects designer construction knowledge. This research provides information on A/E/C industry fragmentation and how it affects the ability of designers to obtain construction knowledge. Several types of fragmentation have occurred in the construction industry, and each of these is discussed.

RESEARCH OBJECTIVE AND PURPOSE

Objective

The objective of this research was to investigate whether the demise of the Master Builder system of project delivery, and the rise of fragmented project delivery systems, has led to a lowering of the level of construction knowledge possessed by designers. This research project also provides recommendations on how designers may obtain appropriate construction knowledge that will allow them to design safer and more efficient projects.

Purpose

The purpose of this research was to investigate the history of project delivery systems from the Master Builder system to the Design/Bid/Build, Construction Management and Design/Build systems in order to determine if there is a relationship between the changes in project delivery systems and the construction expertise of designers. Surveys and interviews were used to determine if there is any correlation between current delivery systems and the effectiveness of designer construction knowledge. This research also investigated whether a Master Builder-type project delivery system increases designer construction knowledge and helps to address constructability issues.

This research investigated historical and current project delivery practices to provide background information on the responsibilities of designers as they relate to construction administration. Surveys and interviews of construction industry professionals were conducted to provide knowledge on the history of project delivery

systems, the level of construction knowledge that designers possess, and the level of design knowledge that contractors possess. The results obtained were used to propose a project delivery system that could be used by design professionals to help them obtain increased construction knowledge and constructability information. In order to reduce the scope of this research, it was limited to architects and civil engineers rather than all design professionals. Additionally, the survey was generally distributed only to individuals in the San Francisco Bay Area of California.

This research project included a survey of executive level, senior level management and entry-level contractors, civil engineers, and architects. A wide cross-section of firms were selected, including firms of different sizes and firms performing different types of work. A survey was used to minimize the time required for obtaining the required information. Due to this research being self-funded, surveys were limited to firms within a reasonable distance of San Jose, California.

CHAPTER 2 RESEARCH METHODOLOGY

Research methods and procedures used for this research project are described in the following sections.

METHODS

The methods that were used include the following:

- A literature review of documentation on the United States construction history.
- A review of current and past construction industry practices.
- A review of project delivery systems.
- A review of construction industry fragmentation and constructability.
- An extensive review of existing literature for articles containing information about designer construction knowledge.
- A survey to determine the various factors related to and involving designer construction knowledge.
- Distribution of the survey to A/E/C industry professionals.
- Development of a custom database using Microsoft Access 2000 for recording survey responses.
- Use of Seagate Crystal Reports 8 and Microsoft Excel 2000 for analysis and charting of survey data results

This research developed a list of construction industry professionals that were surveyed to obtain additional information regarding designer construction knowledge. A standardized questionnaire was developed and used to obtain information from A/E/C industry professionals related to designer construction knowledge. The results obtained were analyzed to determine if there is a need for a unified project delivery system and additional training for construction designers on construction methods. Recommendations were developed on how to improve the construction knowledge of architects and design engineers.

The first phase of the research explored existing literature and research in the area of designer construction knowledge. A list of previous research projects was compiled and used as a resource for this research project. In addition to the literature review, a thesis proposal was prepared for approval by the author's facility advisor Dr. Janet K. Yates. The thesis proposal included an introduction, problem statement, research objective, purpose, research scope, background information, literature review, research methodology, conclusions, references and supplemental references. Most of these sections were included as part of this thesis. The final part of this initial phase was the development of the hypothesis/hypothesizes.

The second phase of this project included conducting a survey of A/E/C construction industry professionals; this required the preparation, distribution, collection and analysis of a questionnaire. The areas of specific interest that were investigated include: design practices, designer knowledge of constructability, project delivery systems, industry fragmentation and the level of designer construction knowledge.

Results from the survey were analyzed and used to test different hypotheses about designer construction knowledge. Appropriate statistical tests were used to analyze the questionnaires results such as: percentage distribution, frequency, mode, maximum, minimum, Spearman's rank correlation, Pearson's correlation coefficient and coefficient of determination.

Research Hypothesis

This research was originally developed based on the researcher's 20 years of industry experience and interest in the Master Builder, constructability, design/build project delivery and the relationship of delivery systems and designer construction knowledge. This led the researcher to hypothesize that designers had been continually disconnected from the construction process. The original hypothesis that was investigated was that designers have had diminished construction knowledge and if this diminished construction knowledge had affects on construction projects. To test this hypothesis a survey was developed to test several areas related to issues regarding company training programs, professional and trade organization membership and participation, project delivery systems, the master builder term and definition, and construction experience and design.

Survey Methods

During the literature review process a survey was developed, along with an agreement letter, a survey cover letter, research intent statement, a confidentiality statement and a survey thank you letter.

The survey consisted of four sections and thirty-two questions. The different sections were divided into: 1) demographic questions about the survey participants and the firms they work for, 2) information on company training programs, 3) information on project delivery systems and 4) information on construction and design experience.

Section I of the survey consisted of demographic questions on the type of firm, years of employment, level of education, current title/position, professional registration,

revenue of the firm and number employees at the firm. The purpose of these questions was to insure that the respondents came from diverse employment backgrounds.

Section II of the survey consisted of questions on company-training programs. This section requested information about the types of training done by companies (formal and on-the-job), types of training subjects, membership in professional or trade organizations, and the number of professional or trade seminars attended by the respondents. Also, this section requested information about whether it was a job function to visit construction jobsites and what types of duties were performed during these visits. The purpose of these questions was to determine the level of training companies are willing to provide and whether those who responded to the survey are keeping up with current methods, practices, technology and materials.

Section III of the survey consisted of questions on project delivery systems. This section requested information about the types of project delivery systems the respondents had participated in at work, the percentage of revenue that their firm performed by project delivery system type, whether their firm had a particular preference for one type of project delivery system and whether the participants were familiar with the term Master Builder and its definition.

Section IV of the survey consisted of questions on construction and design experience. This section asked respondents to provide responses to questions about construction field experience, construction methods, construction processes, construction management, professional registration, and errors and omissions insurance and how these relate to construction field experience. This section also requested respondents to identify

what levels of construction field experience are needed related to design, company training, and on-site observation that would enhance design capabilities and educational requirements for construction knowledge.

In addition to developing these documents, permission to conduct research involving human subjects was required by San Jose State University Human Subjects – Institutional Review Board. To obtain approval for the use of human subjects the researcher was required to submit a completed "Request to Use Human Subjects in Research Cover Sheet", a succinct statement of purpose and justification, hypothesis or questions to be addressed and a methods section. The original request to use human subjects was submitted on February 19th, 2000, upon review by the Institutional Review Board it was requested that all documents be issued on San Jose State University letterhead. After resubmitting these documents as requested on March 13th, 2000 the Institutional Review Board granted approval of the research on March 17th, 2000.

The research survey, letter of introduction, confidentiality agreement, agreement to participate and research intent (Appendices #1-5) were originally developed manually and then transferred into a Microsoft Word 2000 document. The original Microsoft Word 2000 documents were transferred into the Meridian Systems, Inc. Prolog 5.1 database. After placement into the Prolog 5.1 database the researcher employed Prolog 5.1 to perform all tracking and mail merge functions for sending surveys and for recording them when they were completed. The first step was transferring all of the names and addresses of design and non-design firms from the master database into the "Thesis Contact

Management" database. This procedure was accomplished using a built-in software routine in the Prolog 5.1 program.

Figure 1 shows the initial computer screen that initiates the mail merge function. The word processor menu is selected with the mail merge and MS Word menu highlighted. The next step, as shown in Figure 2, displays the mail merge document selection screen with the "Survey Letter" highlighted. After selecting the mail merge document the database advances to the "Contact Pick List" shown in Figure 3. To select a mail merge contact the name of the recipient is double clicked and the "OK" button is selected. Once the mail merge is completed the documents were printed using a high speed laser printer.

The next step was analyzing the survey results and reporting the results. The results were categorized by firm type and the statistical tests used were the distribution analysis, Pearson's product moment correlation, and coefficient of determination.

After the surveys were returned, the researcher developed a Microsoft Access 2000 database for entering and storing the survey responses (Figure Nos. 4 through 7). This database was subdivided into four (4) separate data entry forms and tables. This separation was used to increase the speed of data entry and processing. Analysis and presentation of the survey data was done using Seagate Software, Inc. Crystal Reports Version 8. Further statistical analyses were performed by importing the results from Crystal Reports Version 8 into Microsoft Excel 2000 spreadsheets. Microsoft Excel 2000 spreadsheets were used to calculate the Pearson's coefficient of correlation (r) and coefficient of determination (r squared or RSQ) results. These tests were selected

because the data collected was generally categorical and were best analyzed using the Pearson's tests.

The researcher obtained permission to use the Blach Construction Company client, consultant and subcontractor database from the company's "Prolog 5.1 Master Database". The initial list of potential survey participants included 214 names from this database and the researcher added another 59 names to the database from the American Society of Civil Engineers San Francisco Section 2000 Roster, The National Association of Industrial and Office Properties-Silicon Valley Chapter Membership Directory and a list of colleagues and contacts that evolved from seventeen years of working in the U.S. construction industry. The survey package was developed in a format that could be sent through email or regular mail. Another 7 survey documents were sent via email. The researcher was also allowed direct access to employees from several firms and eleven of the surveys were distributed during a presentation. A total of 291 surveys were distributed to personnel listed in the database; and a total of 89 responses were returned for a response rate of 30.6 %.

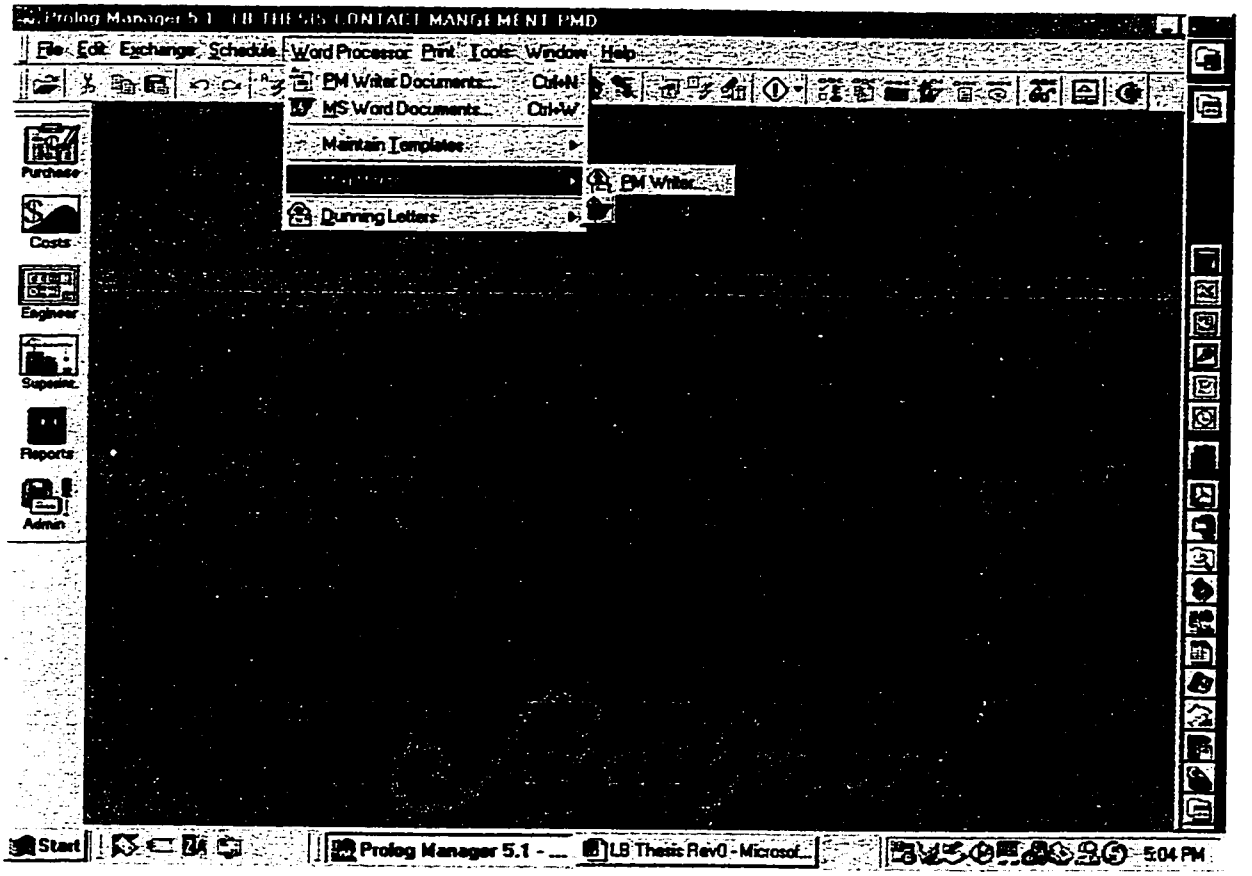


Figure 1 - Prolog 5.1 Word Processor for Mail Merge Screen

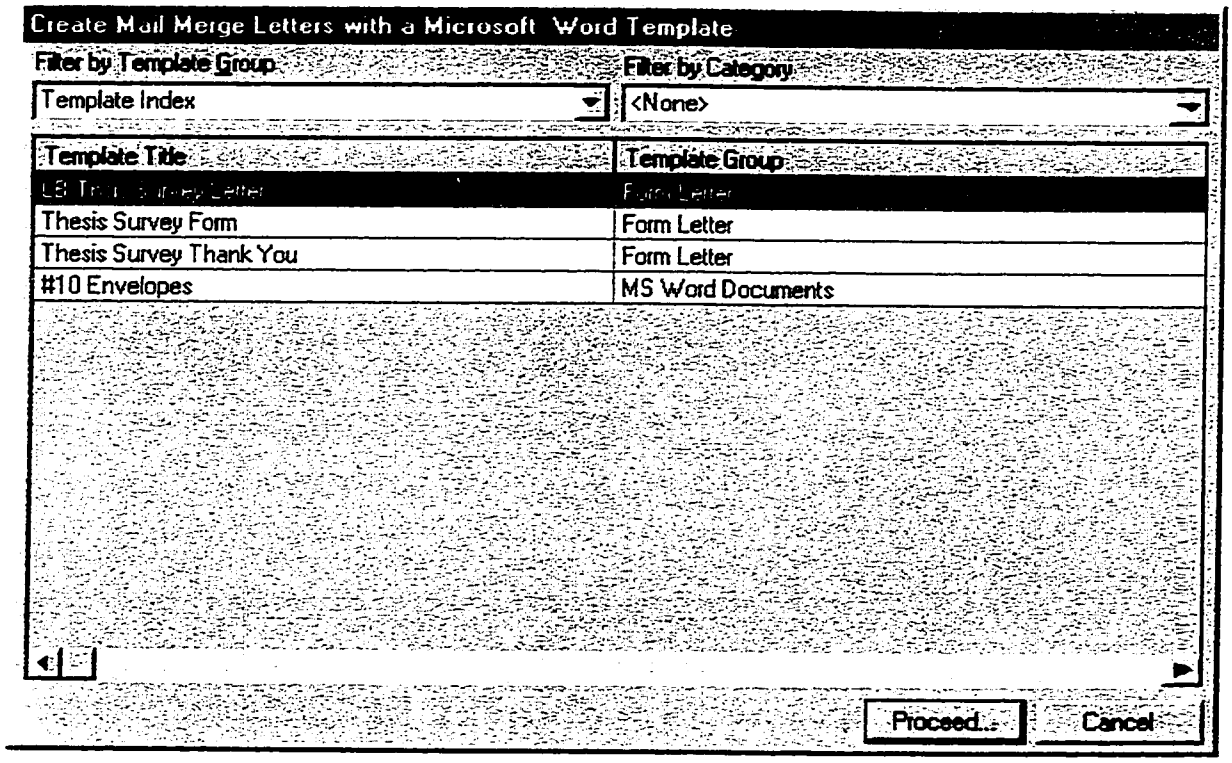


Figure 2 - Prolog 5.1 Mail Merge Selection Screen

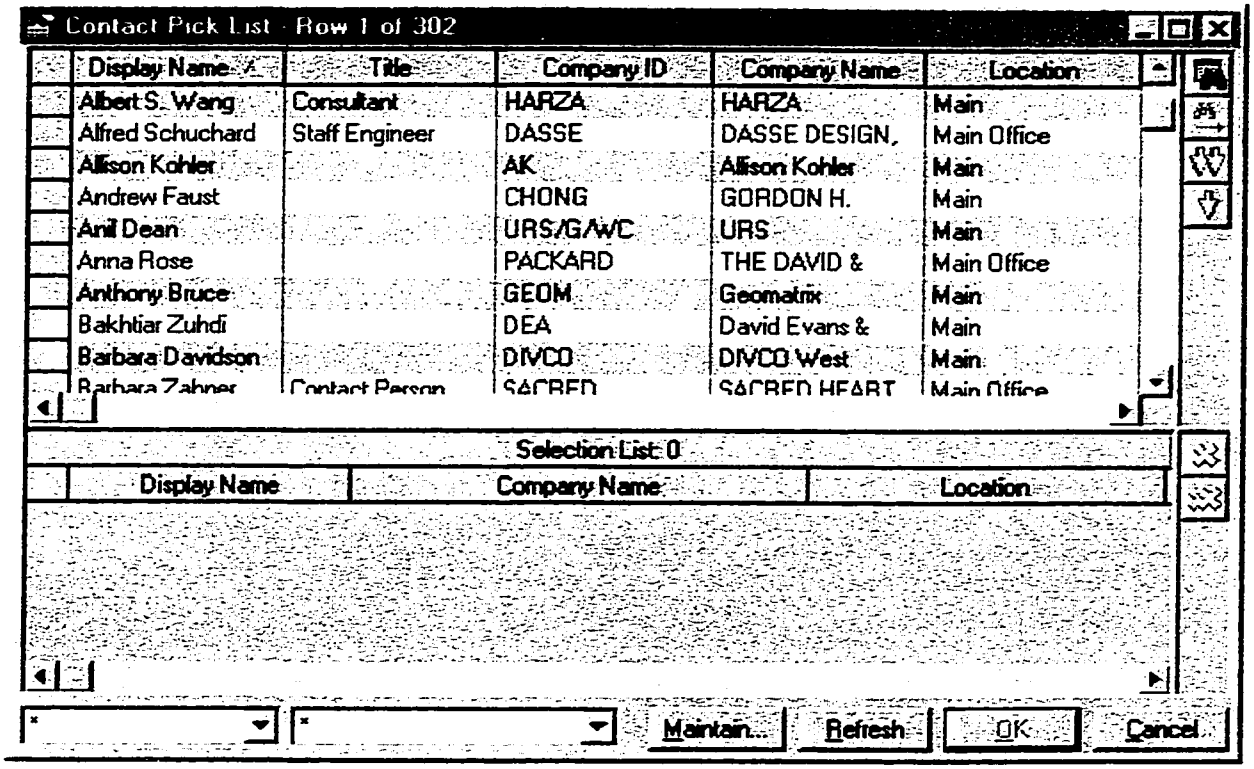


Figure 3 - Prolog 5.1 – Mail Merge Contact Selection Screen

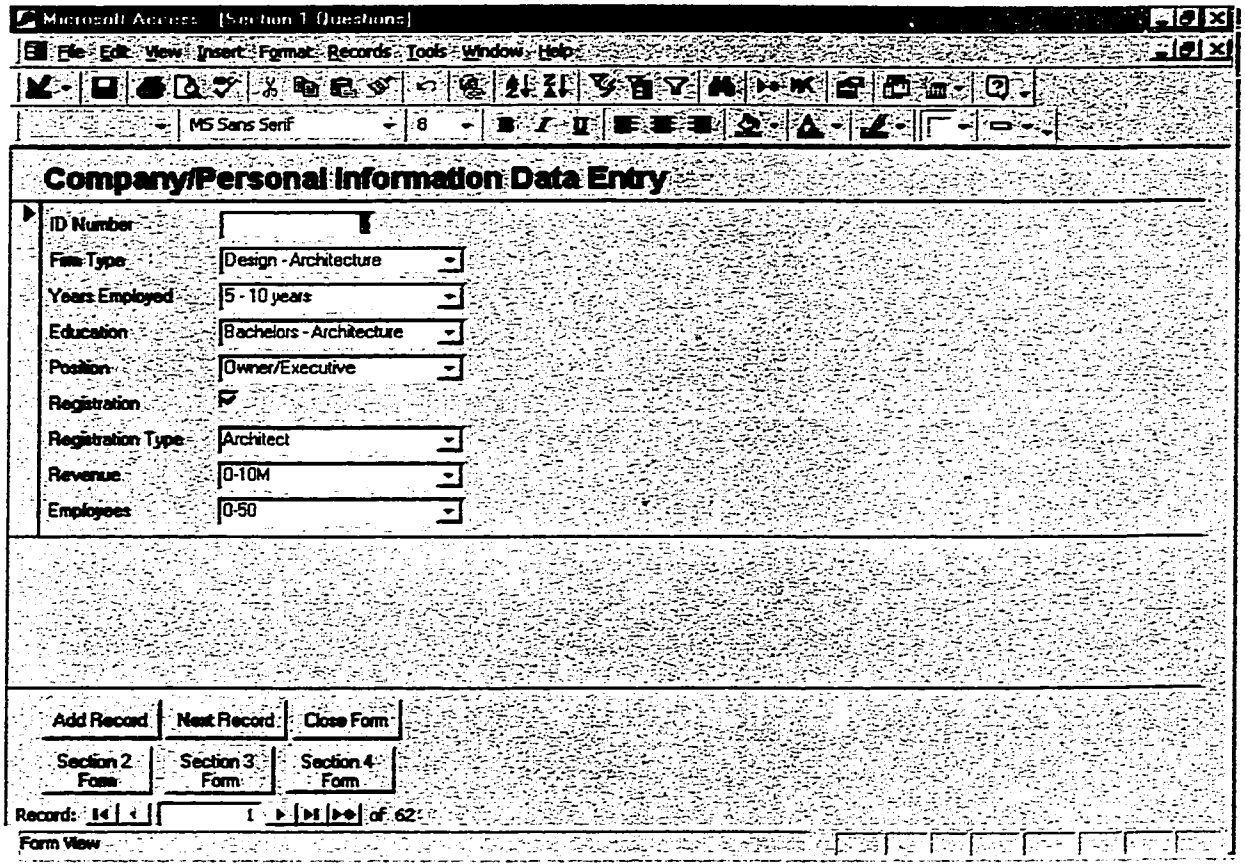


Figure 4 - Survey Data Entry Form for Section 1

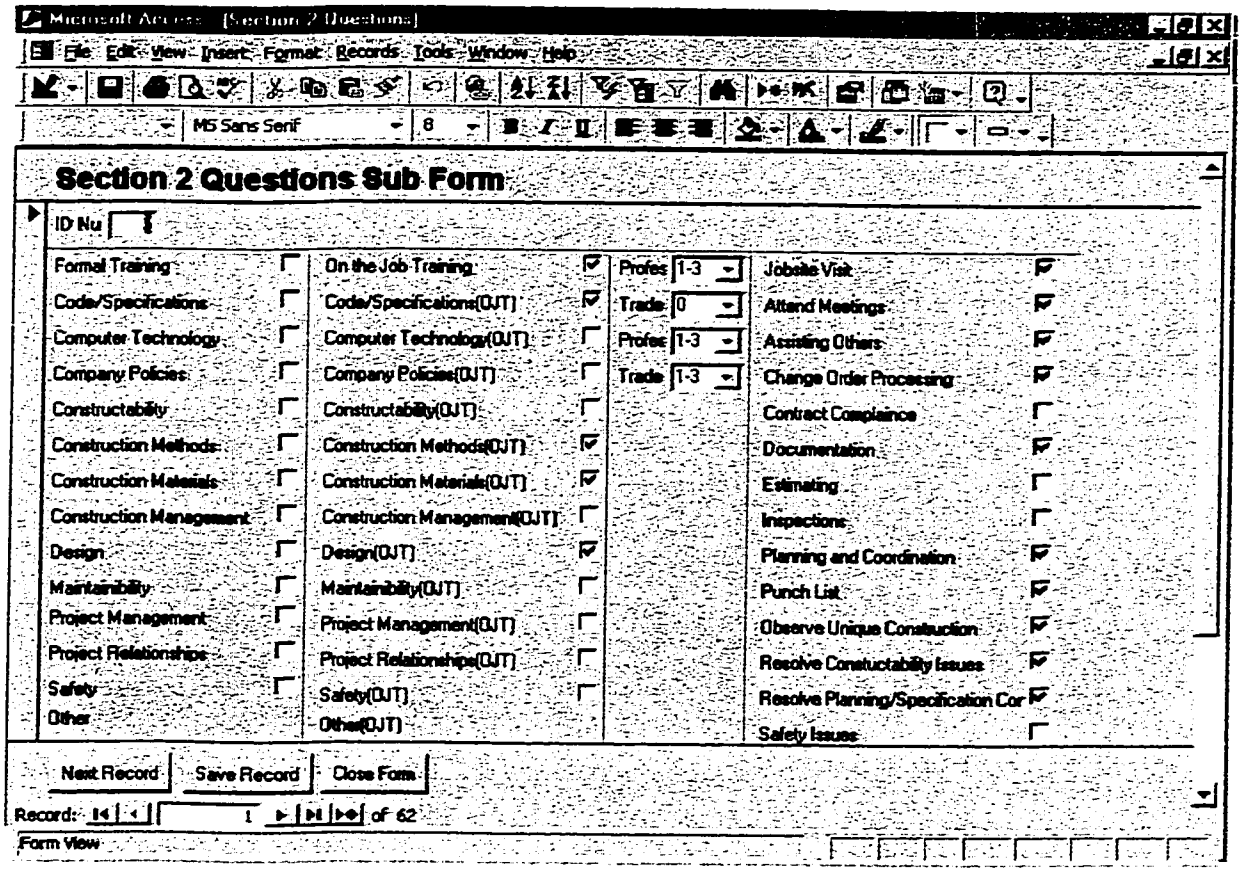


Figure 5 - Survey Data Entry Form for Section 2

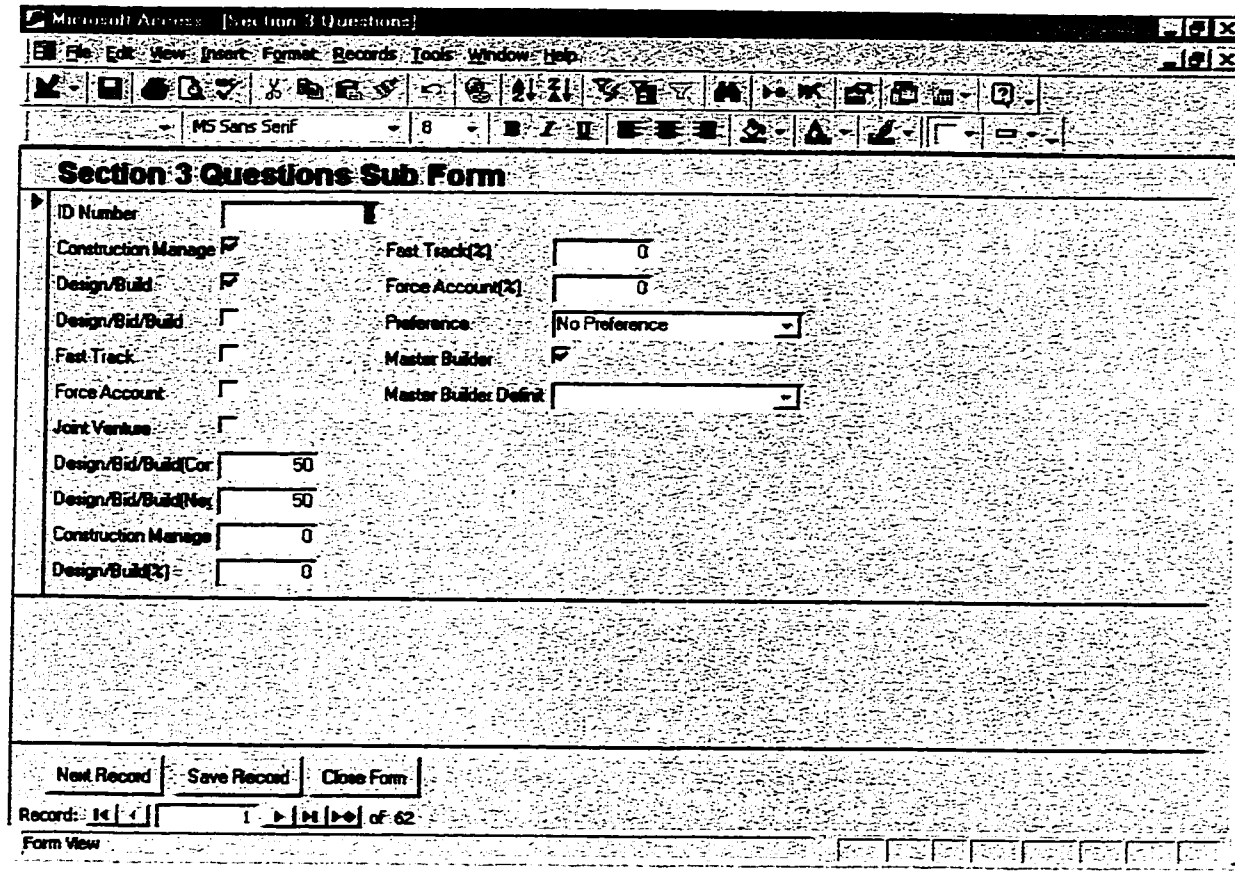


Figure 6 - Survey Data Entry Form for Section 3

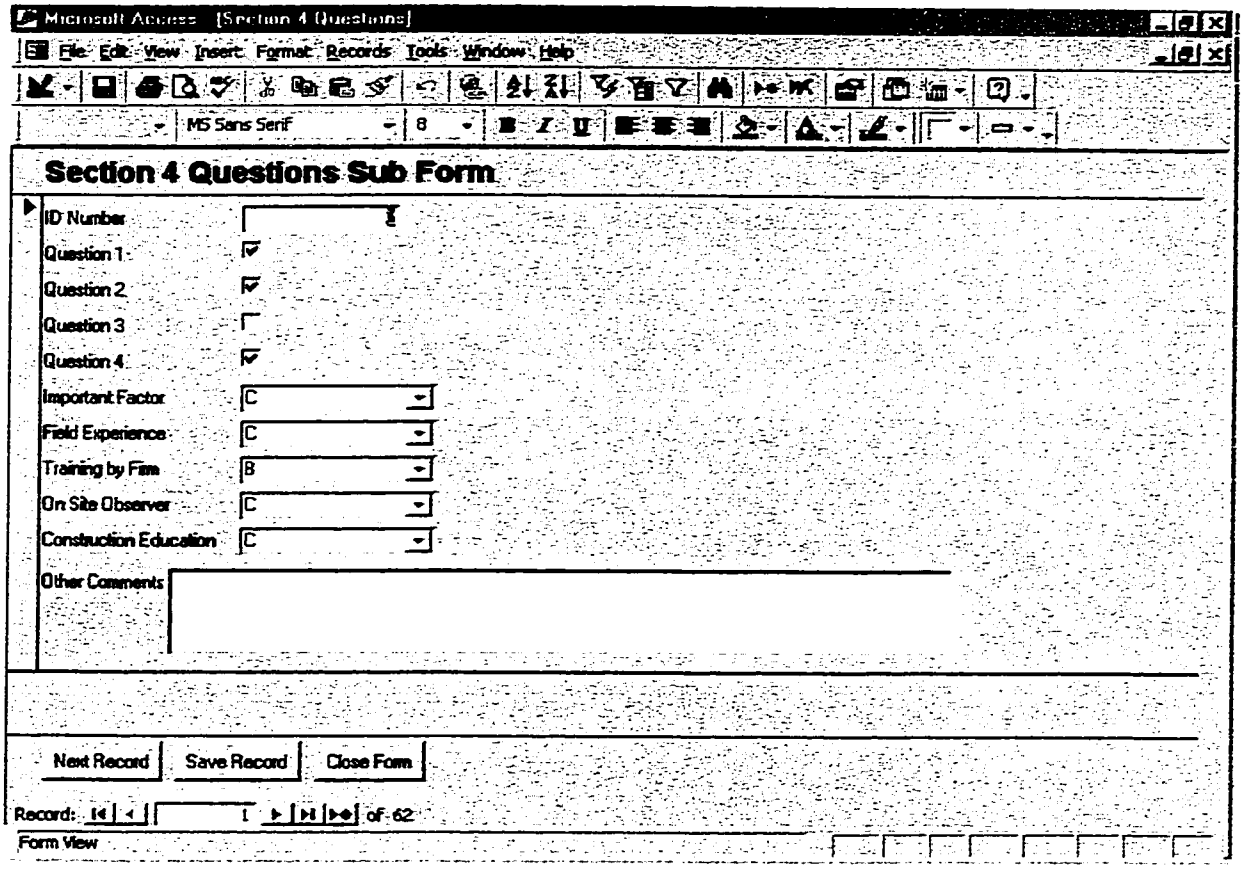


Figure 7 - Survey Data Entry Form for Section 4

CHAPTER 3 LITERATURE REVIEW

This section provides a summary of the information obtained during the literature review for this project.

A Brief History of Construction in the United States

The first European settlers established the United States construction industry and the first projects constructed in the United States were built in the early seventeenth century. The construction industry became organized with the establishment of the Carpenters Company in Philadelphia, Pennsylvania in 1724 and this was the first formal establishment of the Master Builder concept in the United States (Conduit 1982). Master Builders were responsible for designing, surveying, and the laying out of construction projects according to the contract documents. In essence, a Master Builder was the architect, engineer, and job superintendent for each project. In the mid-eighteenth century other Master Builder organizations were established in New York and Boston. During the late nineteenth and early twentieth centuries, the function of the Master Builder fragmented into designer and constructor specialties and this led to the demise of the Master Builder system for building projects (Konchar and Sanvido 1998).

Late in the nineteenth century, construction and design specialists began to contract separately for their specific services and small local companies handled most of the construction. Some major projects were completed during this time, with the most important structure being the Brooklyn Bridge that was built by the members of the Roebling Company. Some of the major contractors that are still in existence today emerged from small family companies such as the Jones Construction Company of North

Carolina, Perini Company of Massachusetts, Grove Construction of Minnesota, Walsh Construction of Iowa, Bechtel Construction Company of California, Guy F. Atkinson Company of California and Kaiser Construction of California and many others (Carty 1995).

The construction industry continued to grow throughout the 1930s, 1940s and 1950s and most of this growth was a result of increased government spending that took place during World War II and its aftermath. During the early 1960s, the industry continued to grow due to large nuclear power plant projects, the federal interstate highway system being built and major airport expansions to allow for jet powered aircraft, and other large projects. During the 1970s, environmental clean-up and oil production projects continued to expand the A/E/C industries (Carty 1995).

In the 1980s, many different large projects were built such as the Crystal Cathedral in Los Angeles, the Chicago Tunneling and Reservoir Project in Chicago, the James Bay Hydroelectric project in Quebec, Canada, the Sunshine Skyway Bridge in Florida, the Upper Stillwater Dam in Montana and another cleanup of Love Canal in New York.

The construction industry experienced a recession in the early 1980s and again in the early 1990s that was caused by federal budget reductions, decreased military spending, and stagnate conditions for private building construction. The period of 1996 - 2000 was a long period of expansion for the construction industry. Much of this expansion was based on an increase in the number of facilities needed by private companies and a modest increase in spending at all government levels.

Project Delivery Systems

The results of many different research projects are available in publications related to project delivery systems such as: the Construction Industry Institute, American Society of Civil Engineers and the American Institute of Architects (Konchar and Sanvido 1998; Warszawski 1975; Vardhan and Yates 1989, and American Institute of Architects California Council 1996). This investigation used the project delivery systems identified by the American Institute of Architects California Council (AIACC 1996), which are shown in the matrix in Figure 8. These project delivery systems fall into three categories: Traditional, Construction Management and Design - Build.

The next section provides information on several different types of project delivery systems.

Traditional Project Delivery

Traditional project delivery systems include Design/Bid/Build (DBB) and the Negotiated Select Team project delivery systems. In the Design/Bid/Build system, the owner of a project has separate contracts with a design firm and a construction firm. Both the contractor and the designer have a contractual relationship with the owner and a non-contractual relationship with each other. In traditional contractual arrangements, the designer is required to complete the design prior to the start of construction (AIACC 1996).

In the Negotiated Select Team (NST) system, each party has a separate contract with the project owner and a non-contractual relationship with each other. However, if the contractor assists during the early design stages this may substantially decrease the

time required to design the project and it might improve the constructability of the project (AIACC 1996).

Construction Management

The construction management system is a system where the construction manager (CM) could be an advisor, an agent, or a constructor (AIACC 1996). The construction manager as an advisor system is one in which the owner has separate contracts with the CM advisor, the designer, and the contractor. As with traditional systems, all parties have non-contractual relationships with each other (AIACC 1996).

The construction manager as an agent is a system where the owner hires the CM to act as his/her agent. The construction manager then contracts with the designer and the contractor for their services. The construction manager has a formal contractual relationship with the owner, the contractor, and the designer. The designer and the contractor have a formal contractual relationship with only the CM/Agent and the designer and the contractor have a non-contractual relationship with each other (AIACC 1996).

The construction manager as a constructor is a project delivery system where the owner contracts with the designer and the construction manager directly. Thus, a contractual relationship exists between the owner, the designer, and the construction manager and a non-contractual relationship exists between the construction manager and the designer. The CM in this system contracts with other prime contractors for construction of the project.

Design-Build

The design/build project delivery system consists of the Design/Build, Design/Build as Developer, and Bridging project delivery systems. In the Design/Build project delivery system the owner contracts directly with a Design/Build entity. The Design/Build entity may be two companies that have a contractual partnership for a particular project (joint venture), or a design firm and a contractor, or a design/build firm. This project delivery system simplifies the contractual arrangements of the owner since the owner has only one contract (AIACC 1996). Design/Build, when done by developers, is similar to the contractual relationship between the owner and a Design/Build entity. However, in this project delivery system the Design/Build entity also handles acquisition of the real estate for the project.

The Bridging project delivery system is also similar to the traditional Design/Build system, however, in this system the owner hires a design consultant that is a separate entity from the Design/Build firm. The design consultant produces the preliminary design documents that are used in the proposal by the Design/Build bidders. A consultant is also involved in the project through completion of construction to ensure that the requirements of the owner are satisfied.

All of the above project delivery systems offer advantages and disadvantages to the owner of a project. The most prevalent project delivery system is the Design/Bid/Build system, however, all other project delivery systems are used with varying results.

Constructability

Many sources are available that contain definitions for the term constructability and the Construction Industry Institute (CII 1986) has defined constructability as: "the optimum integration of construction knowledge and experience in planning, engineering, procurement, and field operations to achieve overall project objectives" (Construction Industry Institute, 1986, p 2). The Construction Management Committee of the American Society of Civil Engineers Construction Division (1986) stated in their article that " Experienced construction personnel need to be involved with the project from the earliest stages to ensure that the construction focus and experience can properly influence owners, planners and designers, as well as material suppliers" (Construction Management Committee of the American Society of Civil Engineers, 1991, p 71), Yates and Vardhan (1989), in their article "A Design Methodology for the Approach of Constructability for Buildings" described constructability as: " A scientific plan of action suitable for optimally configuring the design of a building so that it can then be optimally constructed at the least possible cost" (Vardham and Yates, 1989, p 3). Hanlon and Sanvido (1995) in their article " Constructability Information Classification Scheme" noted that: "It is recognized that the integration of construction information in the early phases of a project provides the best opportunity for cost and time savings" (Hanlon and Sanvido, 1995, p 337). The commonality of all these definitions is the incorporation of construction knowledge into the early design stages of a proposed facility to help reduce the scheduled time and costs.

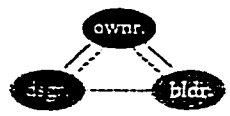
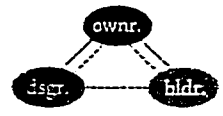
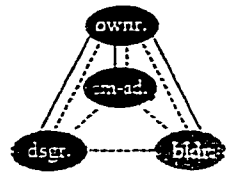
Construction Cost Influence

Many publications discuss the relationship between project costs and the ability to influence those costs. Two of the more common references related to cost influence come from Paulson (1976) as shown in Figure 9 and the Construction Industry Institute (1986) which is shown in Figure 10. Both Figure 9 and Figure 10 display the relationship between project costs and the influence that can be exerted on costs versus the project life cycle. Paulson has stated that (Paulson, 1976, p 589 -599):

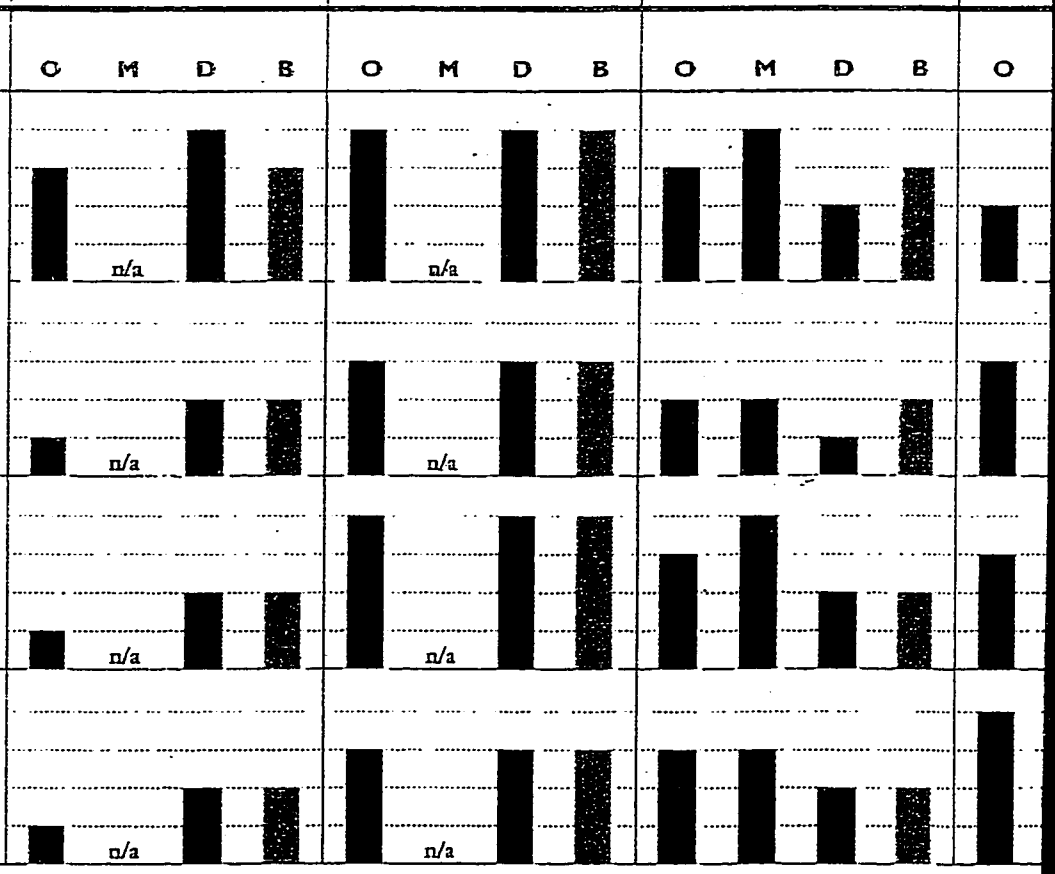
> "On the first day, management has 100% level of influence in determining future expenditures. As these decisions evolve and commitments are made, the remaining level of influence on what project costs will ultimately be drops off precipitously. For example, a rough educated guess would put the remaining level of influence at about 25% of the original by the time field construction commences on a grass roots petroleum refinery."

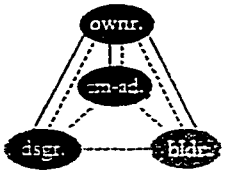
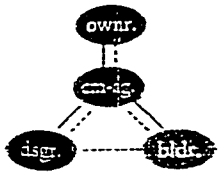
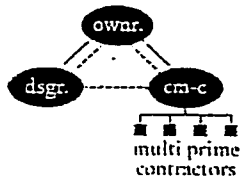
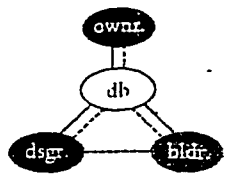
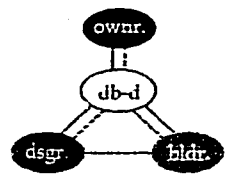
Gibson, Kaczmarowski and Lore in Preproject – Planning Process for Capitol Facilities have indicated that: " Many experts within the construction industry believe that planning efforts conducted during the early stages of a project have a significantly greater effect on project success than efforts undertaken after the project is under way" (Gibson, G. E., Kaczmarowski, J. H.. and Lore, H. E., 1995, p 312). Figure 11 shows another version of the cost/influence diagram by Gibson, Kaczmarowski and Lore (1995). One important factor to note in these figures is that the cost to implement changes is lowest during the design phase and highest during the construction phase. Additionally, these diagrams indicate that final project costs are influenced the most during the design phase.

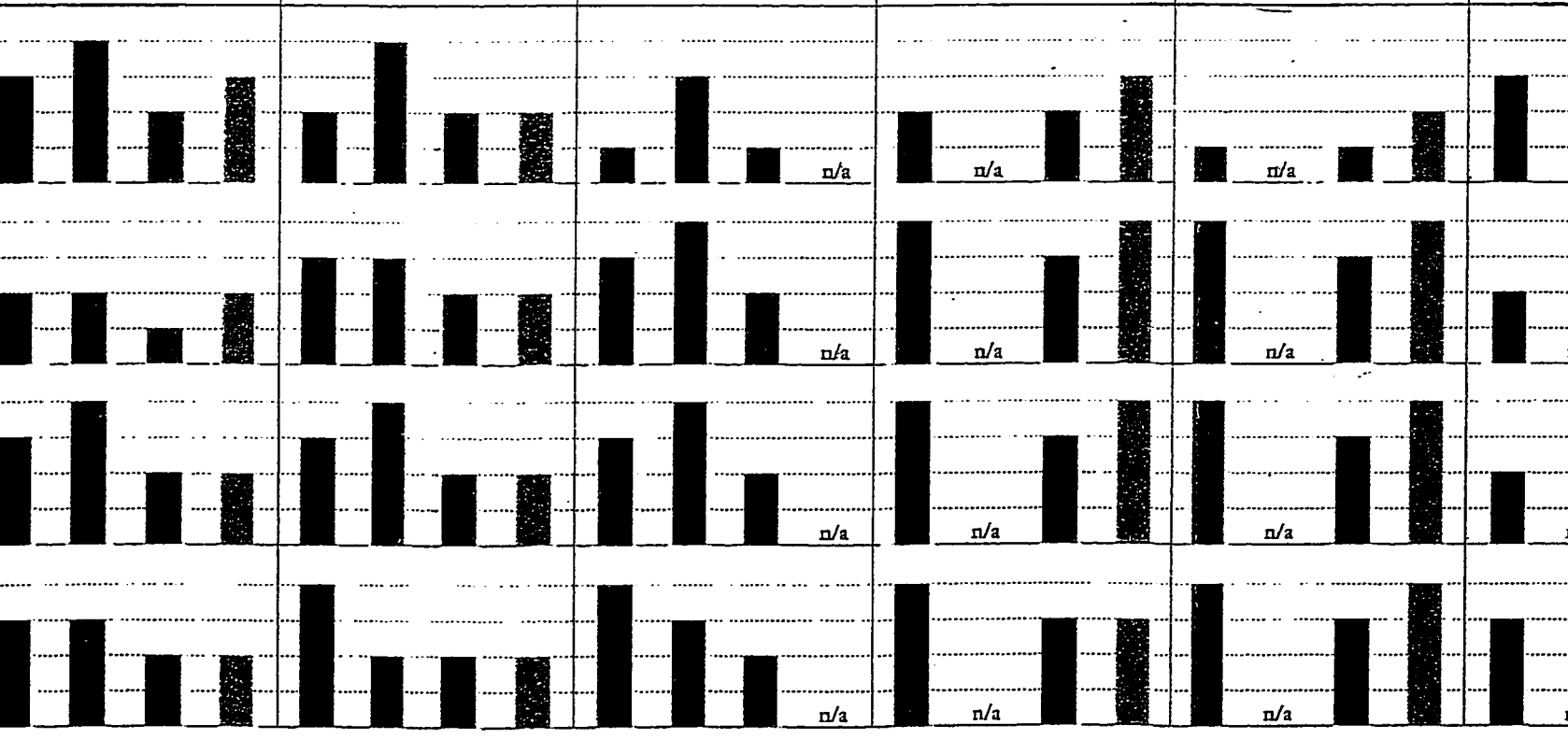
MATRIX OF PROJECT DELIVERY METHODS

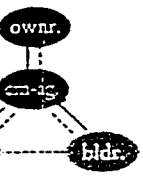
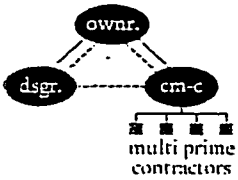
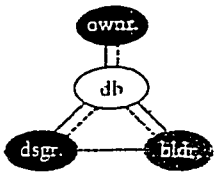
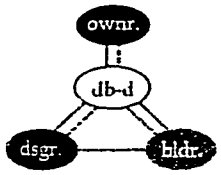
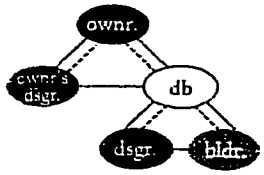
		A1. DBB	A2. NST	B1. CM-Advisor	B2
					
Characteristics		Three linear phases: Design, bid, build. Three prime players: Owner, Designer, Builder. Two separate contracts: Owner to Designer and Owner to Builder. Formal relationship.	Three continuous phases: Design, negotiate, build. Three prime players: Owner, Designer, Builder. Two separate contracts: Owner to Designer and Owner to Builder. Informal relationship.	Three linear phases: Design, bid, build. Four prime players: Owner, CM-Advisor, Designer, Builder. Three separate contracts: Owner to CM-Advisor, Owner to Designer and Owner to Builder. Formal relationship.	Three li Design, Four pri Owner, Designe Three s Owner CM-Ag CM-Ag Formal
Responsibilities	Owner	Program, finance, mgt.	Program, finance, mgt.	Program, finance	Program
	Manager	n/a	n/a	Coord. of Dsgnr. and Bldr.	Legal ag
	Designer	All normal services	All normal services	All normal services	All nor
	Builder	Prime and sub construction	Prime and sub construction	Prime and sub construction	Prime a
Selection Process	Owner	n/a	n/a	n/a	n/a
	Manager	n/a	n/a	Qualifications	Qualifi
	Designer	Qualifications	Qualifications/negotiations	Qualifications	Qualifi
	Builder	Lowest responsible bid	Qualifications/negotiations	Lwst. rsp. bid or negot.	Lowest

Perspectives of Owner, Manager, Designer, & Builder



B1. CM-Advisor	B2. CM-Agent	B3. CM-Constructor	C1. Design-Build	C2. DB-Developer	C
					
Three linear phases: Design, bid, build. Four prime players: Owner, CM-Advisor, Designer, Builder. Three separate contracts: Owner to CM-Advisor, Owner to Designer and Owner to Builder. Formal relationship.	Three linear phases: Design, bid, build. Four prime players: Owner, CM-Agent, Designer, Builder. Three separate contracts: Owner to CM-Agent, CM-Agent to Designer and CM-Agent to Builder. Formal relationship.	Three linear phases: Design, bid, build. Three prime players: Owner, Designer, CM-Constructor. Two separate contracts: Owner to CM-Constructor and Owner to Designer. Formal relationship.	Two continuous phases: Design and build. Two prime players: Owner and Design-Build Entity. One contract: Owner to Design-Build Entity. Formal relationship.	Two continuous phases: Design and build. Two prime players: Owner and DB-Developer. One contract: Owner to DB-Developer. Formal relationship.	Four lin Prelimin design a Three pr Owner, Design- Two sep Owner t Owner t Entity. Formal r
Program, Finance Coord. of Dsgnr. and Bldr. All normal services Prime and sub construction	Program, Finance Legal agent for owner All normal services Prime and sub construction	Program, finance Coord. Dsgnr. prior to const. All normal services CM is prime w/ subcontr.	Program, finance n/a Special services under DB DB is prime w/ subcontr.	Program n/a Special services under DB Finance, prime w/subcontr.	Program n/a Owner's Prime an
n/a Qualifications Qualifications Lwst. rsp. bid or negot.	n/a Qualifications Qualifications Lowest responsible bid	n/a Qualifications Qualifications Qualifications/negotiations	n/a n/a Qualifications/negotiations Lwst. rsp. bid or negot.	n/a n/a Qualifications/negotiations Lwst. rsp. bid or negot.	n/a n/a Qualific Lwst. rsp
O M D B	O M D B	O M D B	O M D B	O M D B	O



CM-Agent	B3. CM-Constructor	C1. Design-Build	C2. DB-Developer	C3. Bridging
				
r phases: d, build. players: M-Agent, Builder. rate contracts: CM-Agent, to Designer and to Builder. tionship.	Three linear phases: Design, bid, build. Three prime players: Owner, Designer, CM-Constructor. Two separate contracts: Owner to CM-Constructor and Owner to Designer. Formal relationship.	Two continuous phases: Design and build. Two prime players: Owner and Design-Build Entity. One contract: Owner to Design-Build Entity. Formal relationship.	Two continuous phases: Design and build. Two prime players: Owner and DB-Developer. One contract: Owner to DB-Developer. Formal relationship.	Four linear phases: Preliminary design, bid, design and build. Three prime players: Owner, Owner's Designer, Design-Build Entity. Two separate contracts: Owner to Owner's Designer, Owner to Design-Build Entity. Formal relationship.
nance for owner services sub construction	Program, finance Coord. Dsgnr. prior to const. All normal services CM is prime w/ subcontr.	Program, finance n/a Special services under DB DB is prime w/ subcontr.	Program n/a Special services under DB Finance, prime w/subcontr.	Program, finance, mgt. n/a Owner's Dsgnr. and DB Dsgnr. Prime and sub construction
 ons ons onsible bid	n/a Qualifications Qualifications Qualifications/negotiations	n/a n/a Qualifications/negotiations Lwst. rsp. bid or negot.	n/a n/a Qualifications/negotiations Lwst. rsp. bid or negot.	n/a n/a Qualifications/negotiations Lwst. rsp. bid or negot.
D B	O M D B	O M D B	O M D B	O M D B

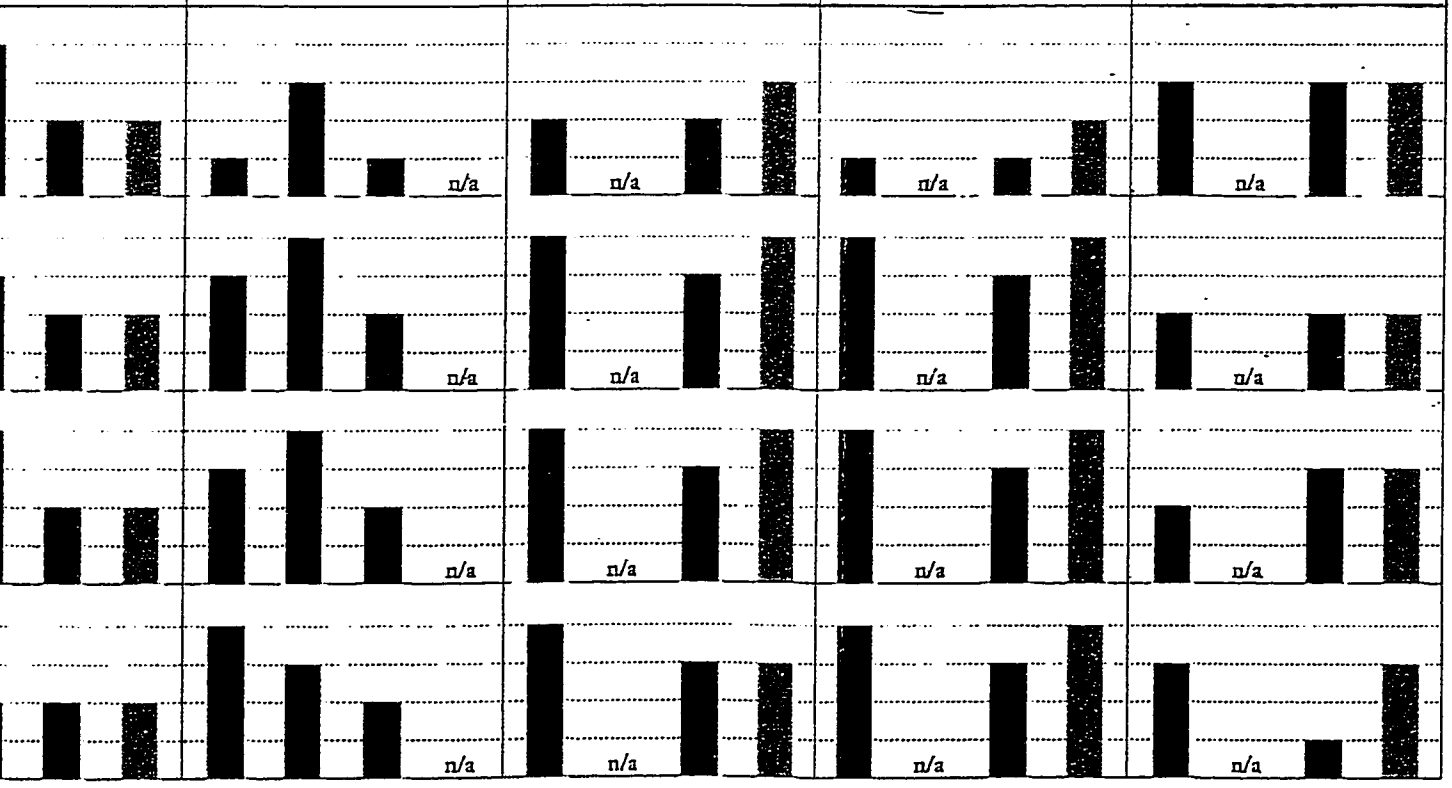


Figure 8- Matrix of Project Delivery Methods

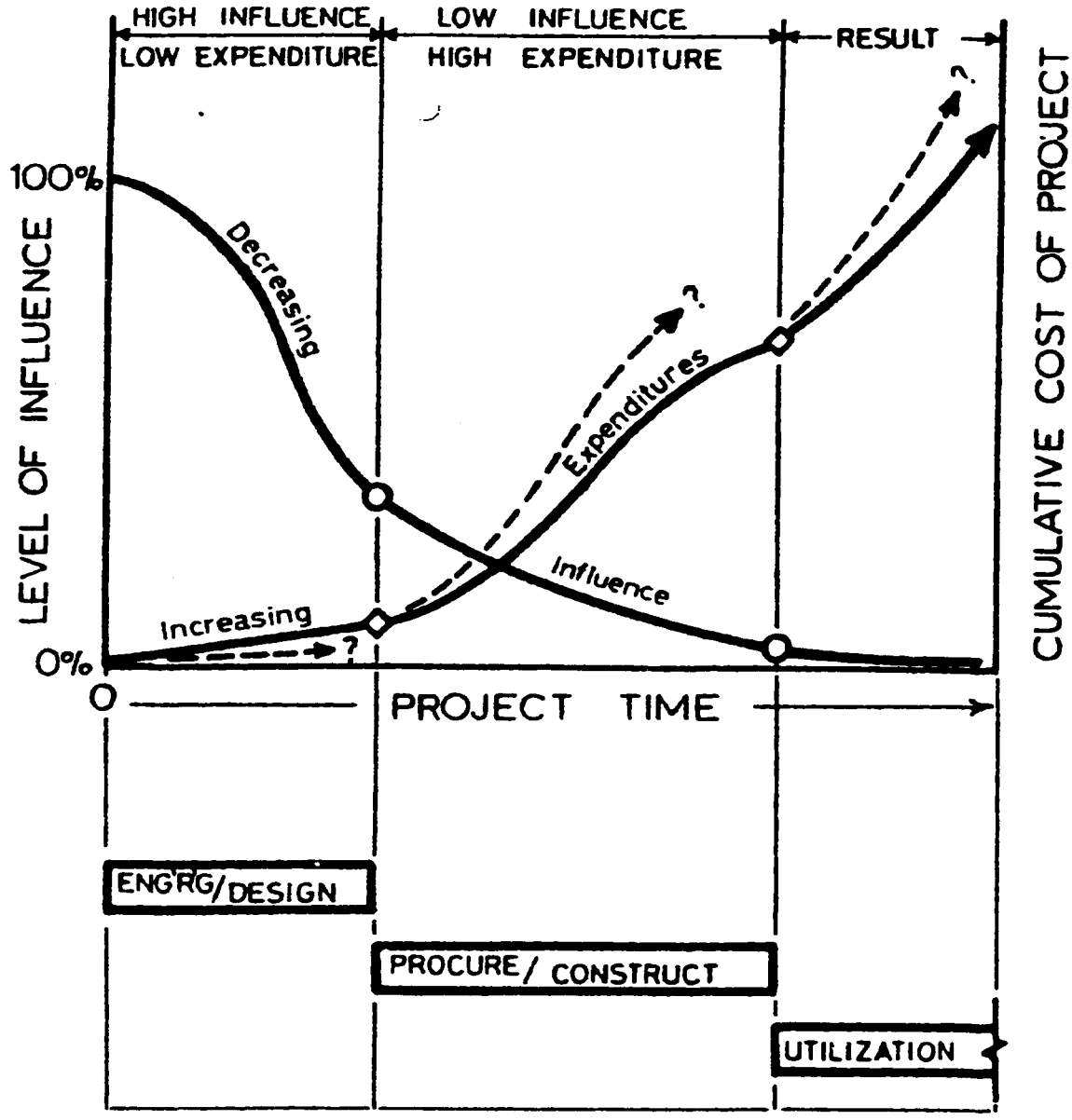


Figure 9 - Level of Influence on Project Costs

(Paulson)

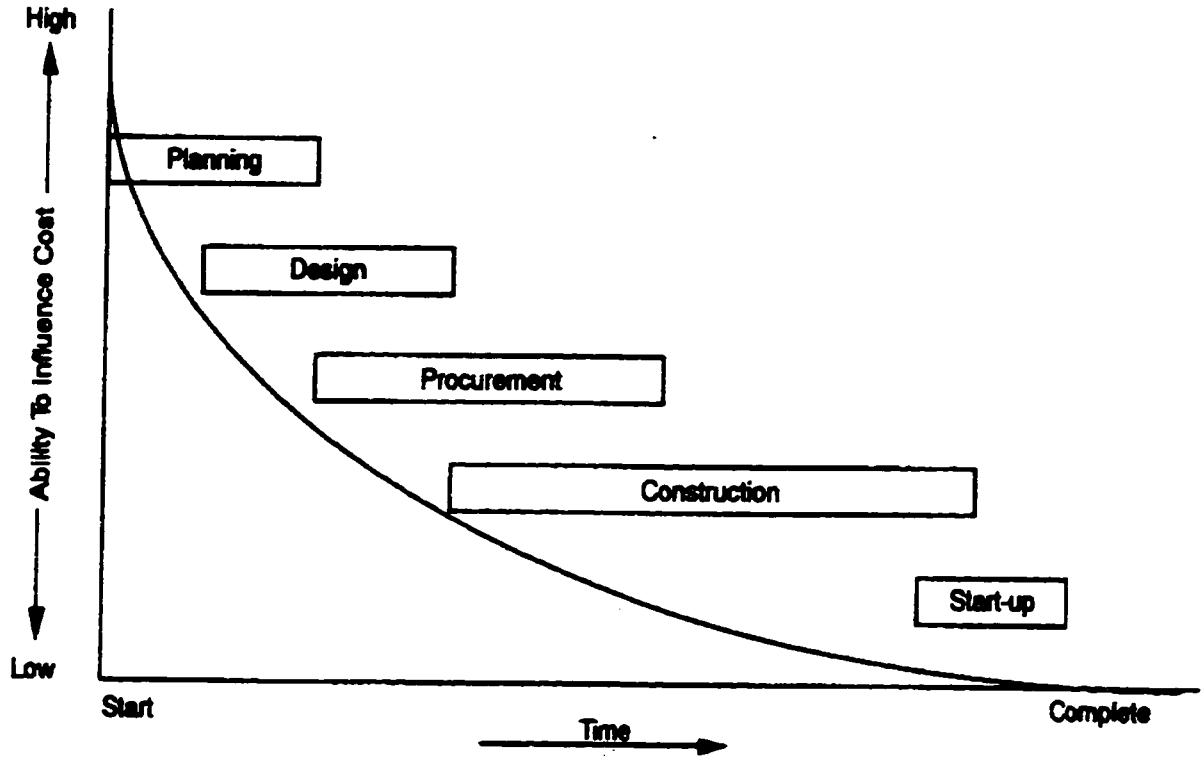


Figure 10 – Ability to Influence Final Cost over Project Life

(Construction Industry Institute)

Constructability Implementation

Previously, the integration of constructability into construction projects was minimal. Fischer and Tatum in the article "Characteristics of Design-Relevant Constructability Knowledge" stated that, " Construction experts are seldom brought into the design office, and generally too late" (Fisher, Martin and Tatum, 1997, p254). Yates and Vardhan in "Constructability in the Professions of Architecture and Construction" said that: " Some designers believe that an evaluation of construction methods feasible on a given site is not necessary while designing buildings" (Yates and Vardhan, 1989, p 2). The Construction Management Committee of the American Society of Civil Engineers in the article "Can Your Design Be Built" indicate that " Many owners, engineers and contractors are still not aware of the potential benefits of improved constructability. Opportunities to reduce the schedule, improve the functionality of the final product, and reduce costs are lost. New construction technology is not applied " (Construction Management Committee of the American Society of Civil Engineers, 1991 p 71). Pocock, Hyun, Liu, and Kim in the article "Relationship Between Project Interaction and Performance Indicators" stated: " Both public and private owners separate design and construction into different functions. Projects are typically transferred from the design organization to the construction organization with little interaction" (Pocock, Hyun, Liu, and Kim, 1996, p 165). Russell and Gugel explained: "Oftentimes, however, construction personnel are not requested to participate in project activities until detailed design is more than 50% complete. Thus, the ability of construction personnel to improve the cost efficiency of the facility is significantly reduced" (Russell and Gugel, 1993, p 769) These

statements indicate that the construction industry is still suffering from minimal input on construction processes during the design phase of projects and this still causes significant problems in the construction industry. Additionally, these statements also point out that many design professionals lack the ability to make good decisions related to construction and constructability issues. Common problems on construction projects include cost overruns, increased construction claims, schedule delays, and poor labor productivity.

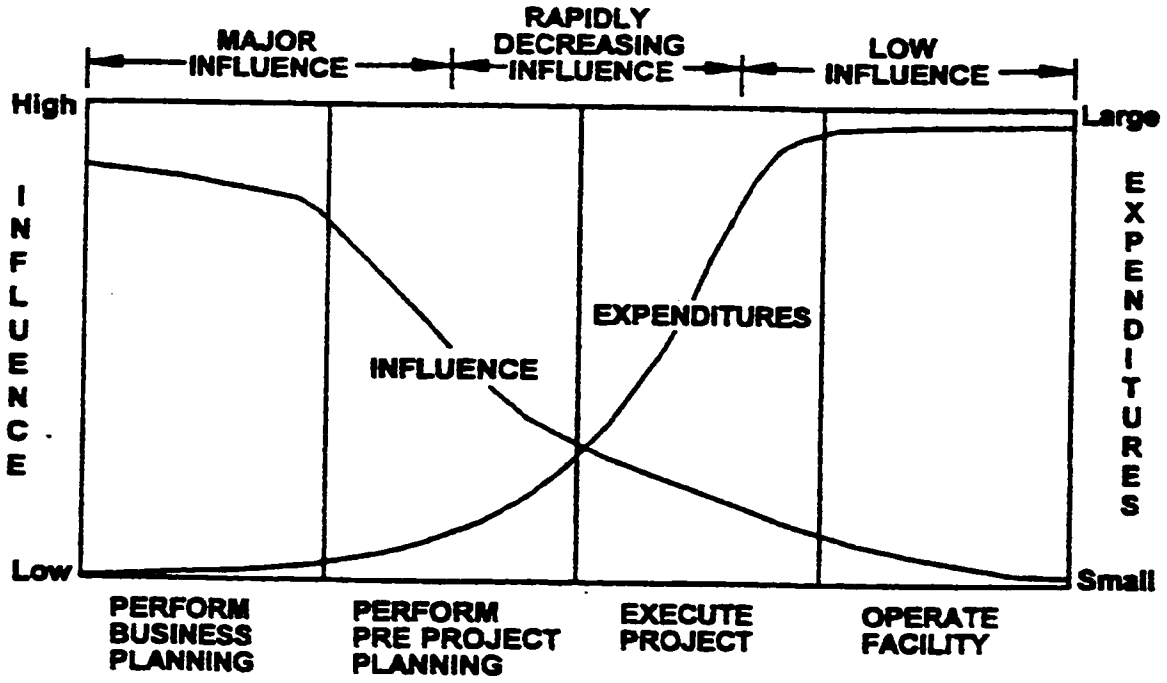


Figure 11 - Influence and Expenditure Curve for Project Life Cycle

(Gibson, Kaczmarowski and Lore)

Industry Fragmentation

The construction industry is fragmented into two different areas. The first area was caused by the separation of the Master Builder function into separate design and construction functions. The second area is the specialization of designers and builders into more specific fields of operation. Examples of this are the different specialties of engineers and architects that are required to design different aspects of a project and also the contractors and subcontractors that build a project (Pocock et al, 1996). Puddicombe stated in "Designers and Contractors: Impediments to Integration" that: " In the building industry these barriers can be much more difficult to surmount. The separation between design and construction is much deeper than that between functional departments. Here we deal with separate companies with widely divergent cultures" (Puddicombe, 1993 p 245). Fischer and Tatum noted in "Characteristics of Design - Relevant Constructability Knowledge" that: "Constructability input is hindered by the partial understanding of construction requirements by designers, the fragmented delivery process, contracting practices, diverging goals between design and construction professionals, and changes in construction methods and materials" (Fischer and Tatum, 1997).

Designer Construction Knowledge

Most of the current publications that address constructability do not state that designers should obtain a certain level of construction expertise prior to starting a design career. These sources often cite contractors, or construction managers, as the main source of constructability information and reviews (Vlatas, 1986; Kirby 1988, and O'Conner, J.T. 1985). Only a few references mention that designers may lack quality construction

knowledge and that this lack of designer construction knowledge may contribute to construction delays, failures, and design errors (Fischer and Tatum 1997). The American Society of Civil Engineers (1986) quoted Mr. George Reider of Constructability Consultants, Ltd: " Many design engineers have never been out in the field and cannot visualize the labor and equipment flow required to perform the project" (p 49), Paulson also notes that: " Knowing how to package separate construction contracts along recognized trade and jurisdictional boundaries, as well as accurate knowledge for estimating time and costs for different operations, are essential. Few design consultants really have such capabilities" (Paulson, 1976, p. 591). Uluatam stated in "Civil Engineering Experience and Education": "It can be strongly advised that civil engineering students have at least a total of six months summer practice on a construction site, which will constitute the first experiences of their professional life" (Uluatam, 1992, p.75). Meryle Secrest in **Frank Lloyd Wright: A Biography** (p.398) stated that:

> " More to the point, perhaps, Wright's concept of what was basically an arts and crafts workshop was being launched at a moment when the concept of the architect was changing, in common with a general shift toward professionalism, from the idea of master builder and toward the theoretical and scholarly. His insistence upon the importance of direct experience and an apprenticeship to the master must have seemed almost an anachronism."

As noted by Chadwick in "Impact of Design, Construction and Cost on Project Quality" a knowledgeable on-site representative of the design firm is "invaluable". Unfortunately, today many projects do not have an on-site design representative and this lack of on-site observation eliminates an important method for designers to observe the construction process and acquire construction knowledge.

In addition to not being formally trained at a construction jobsite, many architectural and civil engineering students complete only a few construction courses in their college programs. Ogelsby noted that: "Most educators in the four year civil engineering programs admit that their programs do not give much attention to construction" (Ogelsby, 1982, p.606). Oberlender states in "Development of Construction Research" "little has been done in research compared to other academic disciplines" (Oberlander, 1984,p. 487).

The construction industry has changed dramatically since the founding of the United States. Most of these changes may have had an unfavorable impact on the quality, cost and duration of construction projects. Specifically, the changes in project delivery systems have had dramatic effects on the industry. This research project (The Master Builder Project Delivery System and Designer Construction Knowledge) not only shows how, when and why these changes have taken place, but it also provides evidence of how the industry can improve designer construction knowledge and project delivery to reduce construction project costs, quality and schedule.

CHAPTER 4 SURVEY RESULTS

This section contains the results that were generated from the data collected from the survey respondents.

Demographic Information

The survey results were first tabulated by company type with the following results (Figure 12):

- 25.8% of the respondents were construction companies (general contractors and specialty subcontractors)
- 4.5% were construction managers.
- 34.8% were designers from architectural firms.
- 19.1% were designers from engineering firms.
- 6.7% were designers from multi-discipline design firms.
- 7.9% were property managers or owners.
- 1.1% were other types of firms.

The surveys were also tabulated by the number years of employment with the following results (Figure 13):

- 12.4% of the respondents had 1-5 years experience.
- 12.4% of the respondents had 5-10 years experience.
- 10.1% of the respondents had 10-15 years experience.
- 64.0% of the respondents had 15 years or more experience.
- 1.1% of the respondents had other experience.

The third tabulation summarized of the surveys was by level of education with the following results (Figure 14):

- 21.4% of the respondents had completed a high school education.
- 26.2% of the respondents had completed a bachelor's degree in architecture.
- 13.1% of the respondents had completed a bachelor's degree in engineering.
- 14.3% of the respondents had completed a bachelor's degree in an area other then architecture or engineering.
- 6.0% of the respondents had completed a master's degree in architecture.
- 8.3% of the respondents had completed a master's degree in engineering.
- 8.3% of the respondents had a master's degree in an area other then architecture or engineering.
- 2.4% of the respondents had a doctorate or higher education with the area not identified.

For the fourth tabulation the surveys were grouped by professional registration:

- 56% of the respondents did not have a professional license.
- 44% of the respondents had a professional license.

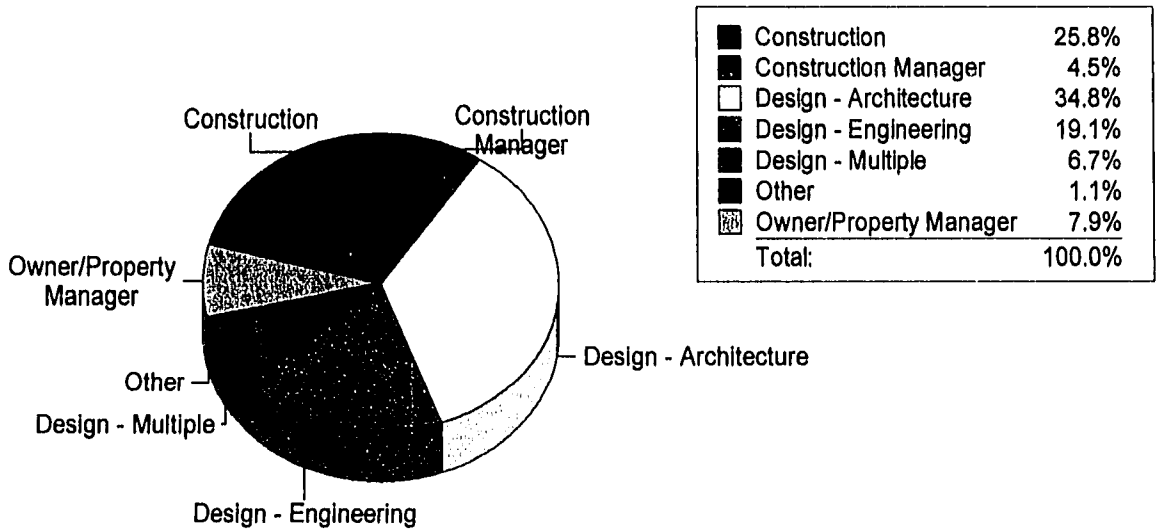
The type of professional registration was also tabulated. Of the licensed professionals 50% had an architecture license and 50% had an engineering license (Figure 15).

For the fifth tabulation the surveys were grouped by the size of the firm by annual revenues (Figure 15):

- 60.7% of the respondents worked for companies with annual revenues below ten million dollars.
- 28.6% of the respondents worked for companies with annual revenues above ten million dollars but below fifty million dollars.
- 4.8% of the respondents worked for companies with annual revenues above one hundred million dollars but below five hundred million dollars.
- 2.4% of the respondents worked for companies with annual revenues above five hundred million dollars but below one billion dollars.
- 3.6% of the respondents worked for companies with other revenues.

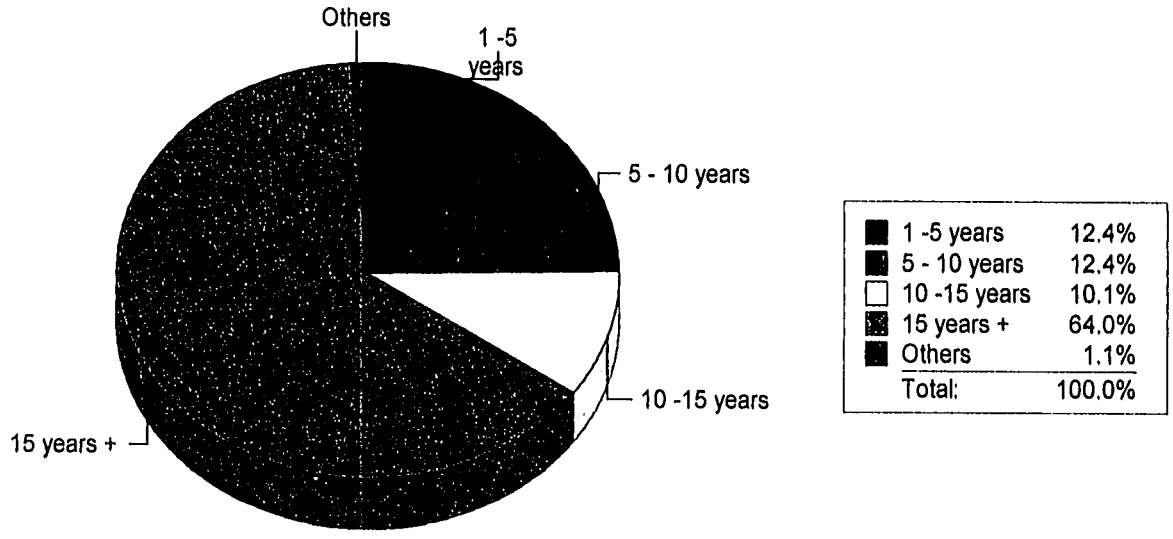
The last tabulation of the surveys were grouped by the size of the firm by number of employees (Figure 16):

- 54.8% of the respondents worked for companies with fifty or fewer employees.
- 23.8% of the respondents worked for companies with more than fifty employees but less then 100 employees.
- 14.3% of the respondents worked for companies with more the one hundred employees but less then five hundred employees.
- 1.2% of the respondents worked for companies with more then five hundred employees but less than one thousand employees.
- 6.0% of the respondents worked for companies with more then one thousand employees.



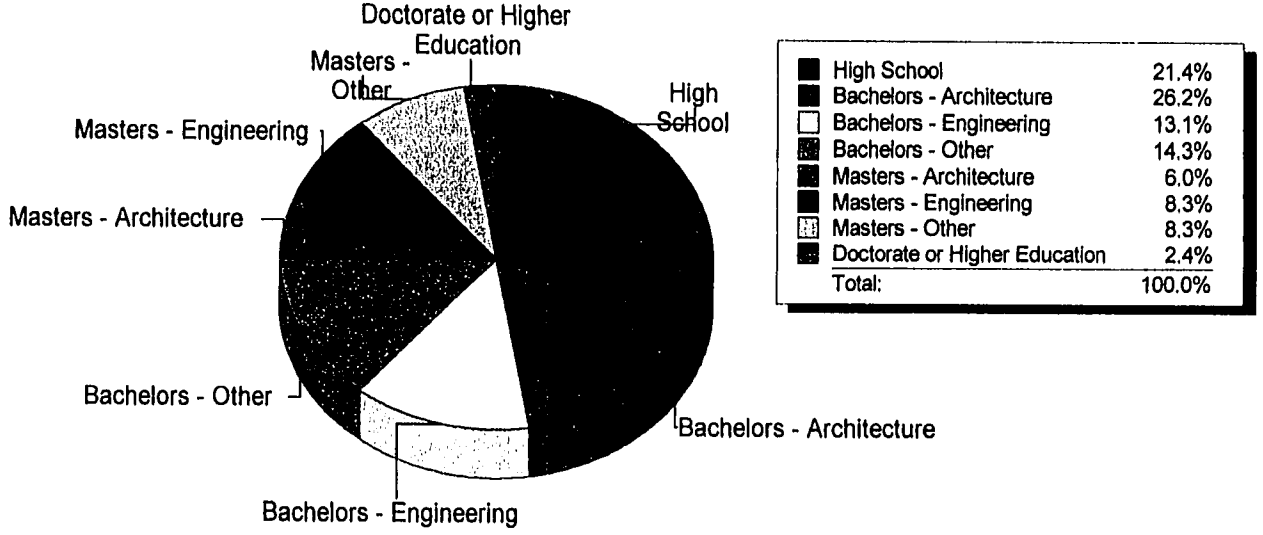
	Construction	Construction Manager	Design - Architecture	Design - Engineering	Design - Multiple	Other	Owner/Property Manager	Total
Total	**23**	**4**	**31**	**17**	**6**	**1**	**7**	**89**

Figure 12 – Survey Respondent Company Type



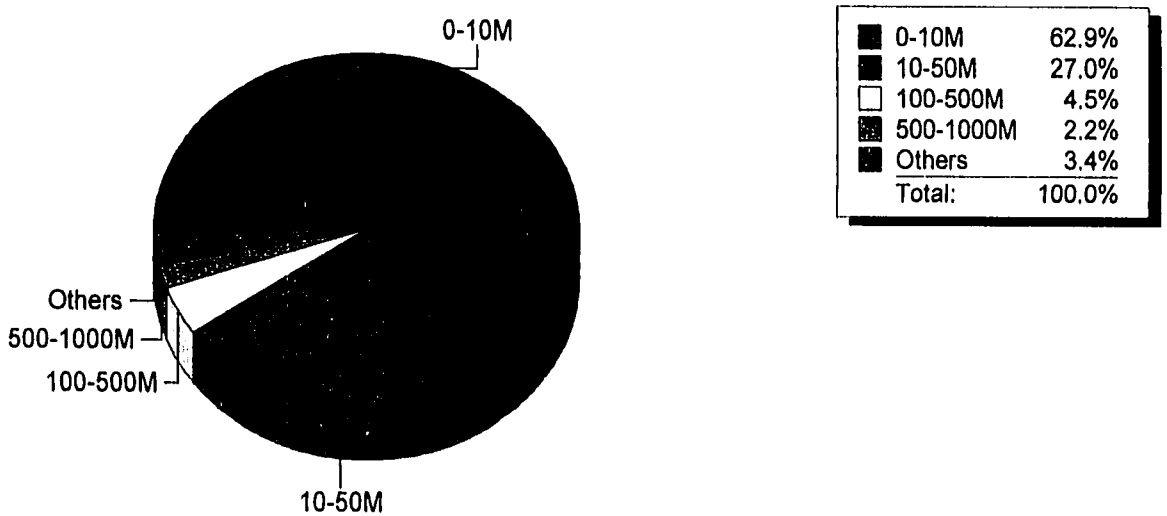
	1-5 Years	5-10 Years	10-15	15 Years +	Other	Total
Total	**11**	**11**	**9**	**57**	**1**	**89**

Figure 13 – Survey Respondents Years of Employment



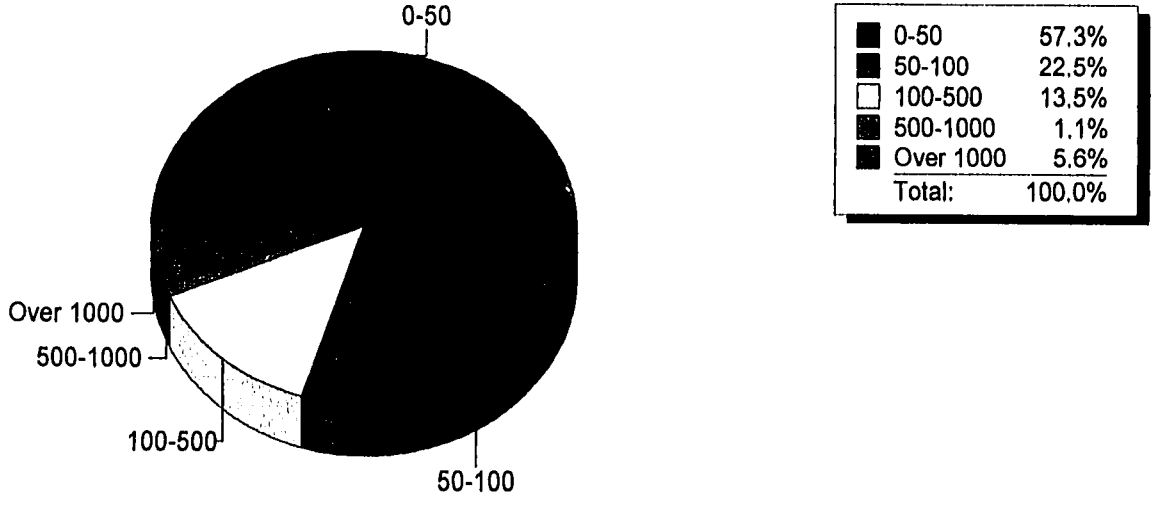
	High School	Bachelors-Architecture	Bachelors-Engineering	Bachelors-Other	Masters-Architecture	Masters-Engineering	Masters-Other	Doctorate Or Higher	Total
Total	**18**	**22**	**11**	**12**	**5**	**7**	**7**	**2**	**84**

Figure 14 – Survey Respondents Education Level



	0-10M	10-50M	100-500M	500-1000M	Others	Total
Total	**56**	**24**	**4**	**2**	**3**	**89**

Figure 15 – Survey Respondents Annual Revenue



	0-50	50-100	100-500	500-1000	Over 1000	Total
Total	**51**	**20**	**12**	**1**	**5**	**89**

Figure 16 – Survey Respondents Number of Employees

Company Training Programs

Formal and On-the-Job Training

The survey requested information from the respondents about any training programs that are used in their companies. The two major types of training used in the survey were formal and on-the-job training programs. The survey responses indicated that 74.0% of the companies do not have formal training programs and 26.0% indicated that their companies offered formal training programs. The survey responses indicated that 60.3% of their companies use on-the-job training methods and 39.7% do not offer on-the-job training. The survey also found that 35.9% of the companies do not use either formal, or on-the-job, training methods and 23.4% of the companies use both training methods.

The survey requested that the respondents indicate the types of training (formal and on-the-job) offered by their companies. The respondents indicated that their firms provided training in the following areas:

- Codes and Specifications
- Computer Technology
- Construction Methods
- Construction Materials
- Company Policies
- Constructability
- Construction Management
- Design
- Maintainability
- Project Management
- Project Relationships
- Safety

The areas of formal training cited as the most common to the least common, as shown in Table 1, were:

- 23.8% Codes/Specifications
- 20.2% Computer Technology
- 16.7% Company Policies
- 13.1% Project Management
- 9.5% Safety, Construction Materials and Design
- 8.3% Construction Methods
- 7.1% Construction Management
- 4.8% Constructability
- 3.6% Project Relationships
- 2.4% Maintainability

The areas of on-the-job training cited as the most common to the least common, as shown in Table 2, were:

- 47.6% Codes/Specifications
- 39.3% Project Relationships
- 38.1% Construction Materials
- 36.9% Company Policies and Construction Management
- 33.3% Constructability
- 26.2% Computer Technology
- 19.1% Project Management, Maintainability and Construction Methods
- 17.9% Safety
- 9.5% Design

Table 1 – Formal Training by Type

Training Type	Codes/ Specifications	Computer Technology	Company Policies	Constructability	Construction Methods	Project Relationships
# of Responses	20	17	14	4	7	3
% of Responses	22.47	19.10	15.73	4.49	7.87	3.37
	Construction Materials	Construction Management	Design	Maintainability	Project Management	Safety
# of Responses	8	6	8	2	11	8
% of Responses	8.99	6.74	8.99	2.25	12.36	8.99

Table 2 – On the Job Training by Type

Training Type	Codes/ Specifications	Computer Technology	Company Policies	Constructability	Construction Methods	Project Relationships
# of Responses	42	23	33	30	16	34
% of Responses	47.19	25.84	37.08	33.71	17.98	38.20
	Construction Materials	Construction Management	Design	Maintainability	Project Management	Safety
# of Responses	33	33	8	16	16	16
% of Responses	37.08	37.08	8.99	17.98	17.98	17.98

Project Delivery Systems

The first part of the survey, in Section III, requested that the respondents provide information on their experience with different project delivery systems and their preferences for a particular delivery system. The first question in Section III asked the participants to identify the project delivery systems that they had participated in at work. The following are the percentages that were indicated by the respondents on their participation in various project delivery systems as shown in Figure 17:

- 50.56% Construction Management
- 70.79% Design/Build
- 77.53% Design/Bid/Build
- 68.54% Fast Track
- 28.09% Force Account
- 22.47% Joint Venture

Section III also inquired as to whether the respondent's company has a particular preference, or endorsed, a particular project delivery system. The following are the percentages of the companies that preferred a particular project delivery system as shown in Figure 18:

- 45.2% Design/Bid/Build (Negotiated)
- 21.4% No Preference
- 15.5% Not Sure
- 7.1% Construction Management
- 6.0% Design/Bid/Build (Competitive)
- 4.8% Design/Build

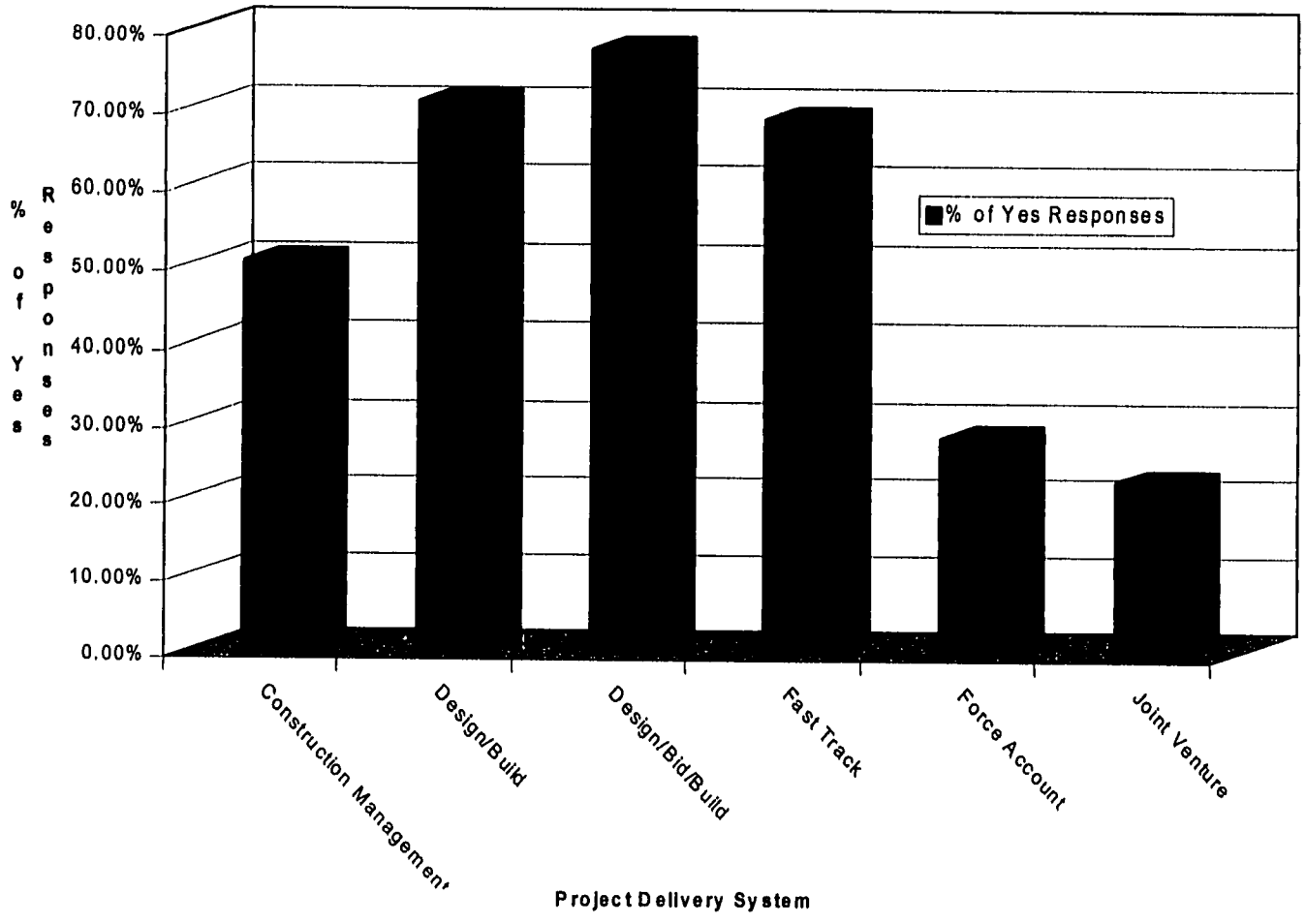
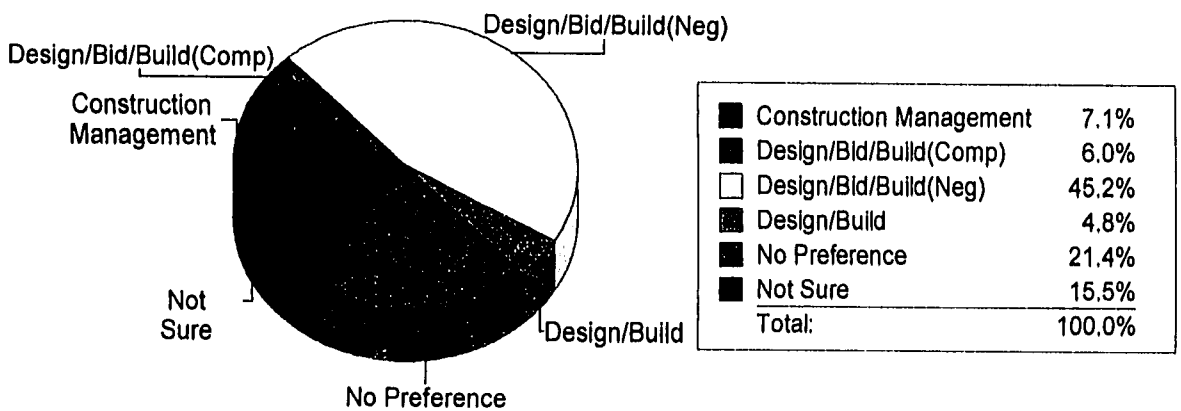


Figure 17 – Project Delivery System Experience



	Construction Management	Design/Bid/Build (Comp)	Design/Bid/Build (Neg)	Design/Build	No Preference	Not Sure	Total
Total	**6**	**5**	**38**	**4**	**18**	**13**	**84**

Figure 18 – Project Delivery System Preference

The Master Builder Term and Definition

The survey also requested information regarding the respondent's knowledge about the term "Master Builder" and the definition of a "Master Builder". In Section III, for question number 4, the respondents were asked the question " Are you familiar with the term Master Builder". The respondents indicated that 57.1% were familiar with the term and 42.9% were not familiar with the term. The survey also requested the respondents to pick a definition that best described their understanding of the term "Master Builder". Of the 89 individuals that responded to the survey, only 69 of them made a selection; 46 responded, "Yes" and 23 responded "No" to question number 4. The combined responses are as follows and are shown in Figure 20:

- 24.6% - A project delivery system that includes all parties involved in a construction project from concept to operation.
- 21.7% - An old construction industry term that is no longer applicable to the construction industry.
- 33.3% - Design firms with Architects and Engineers highly trained and educated that have extensive knowledge of both design and construction that also provide construction services.
- 10.1% - Contractors that employ designers to handle all phases of a project from concept to operation.
- 10.1% - Construction and design firms that perform projects via the Design/Build project delivery.

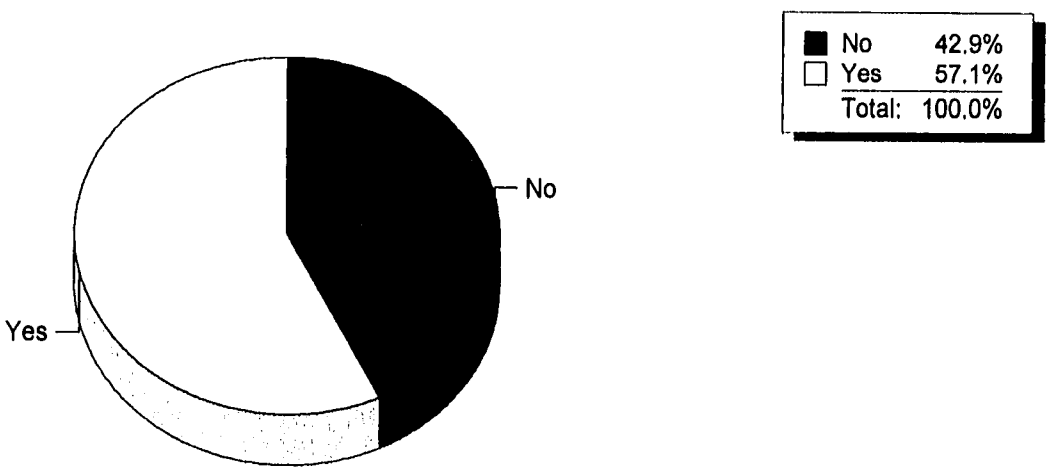
An analysis of the responses was performed to show the differences between those that responded, "Yes" and those that responded "No" to question number 4. The respondents that answered, "Yes" indicated the following as shown in Figure 21:

- 21.7% of the "Yes" respondents selected - A project delivery system that includes all parties involved in a construction project from concept to operation.
- 28.3% of the "Yes" respondents selected - An old construction industry term that is no longer applicable to the construction industry.

- 34.8% of the "Yes" respondents selected - Design firms with Architects and Engineers highly trained and educated that have extensive knowledge of both design and construction that also provide construction services.
- 4.3% of the "Yes" respondents selected - Contractors that employ designers to handle all phases of a project from concept to operation.
- 10.9% of the "Yes" respondents selected - Construction and design firms that perform projects via the Design/Build project delivery.

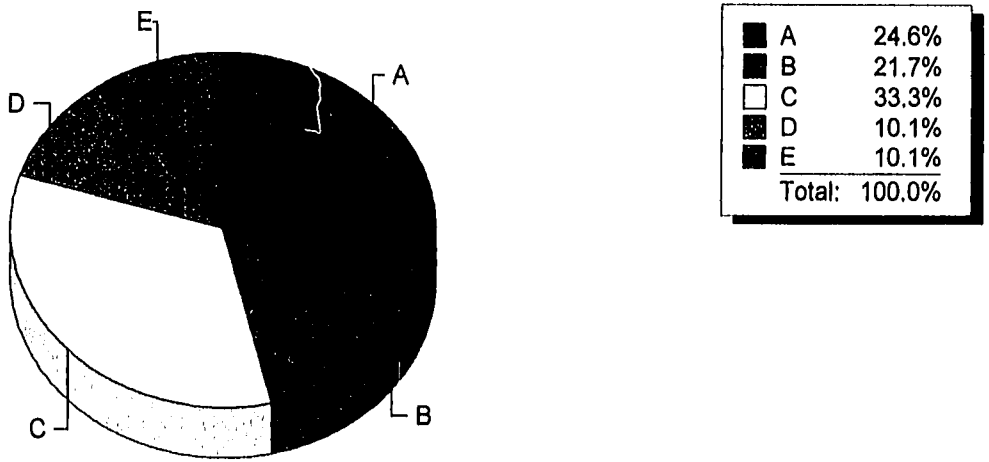
For those that responded "No" to question number 4 the following results were obtained and as shown in Figure 22:

- 30.4% of the "No" respondents selected - A project delivery system that includes all parties involved in a construction project from concept to operation.
- 8.7% of the "No" respondents selected - An old construction industry term that is no longer applicable to the construction industry.
- 30.4% of the "No" respondents selected - Design firms with Architects and Engineers highly trained and educated that have extensive knowledge of both design and construction that also provide construction services.
- 21.7% of the "No" respondents selected - Contractors that employ designers to handle all phases of a project from concept to operation.
- 8.7% of the "No" respondents selected - Construction and design firms that perform projects via the Design/Build project delivery.



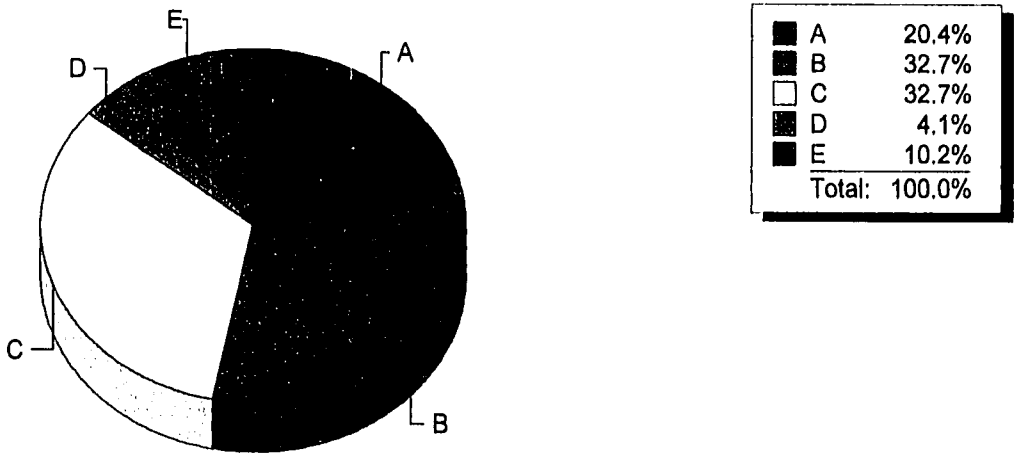
	No	Yes	Total
Total	**36**	**48**	**84**

Figure 19 – Master Builder Identification



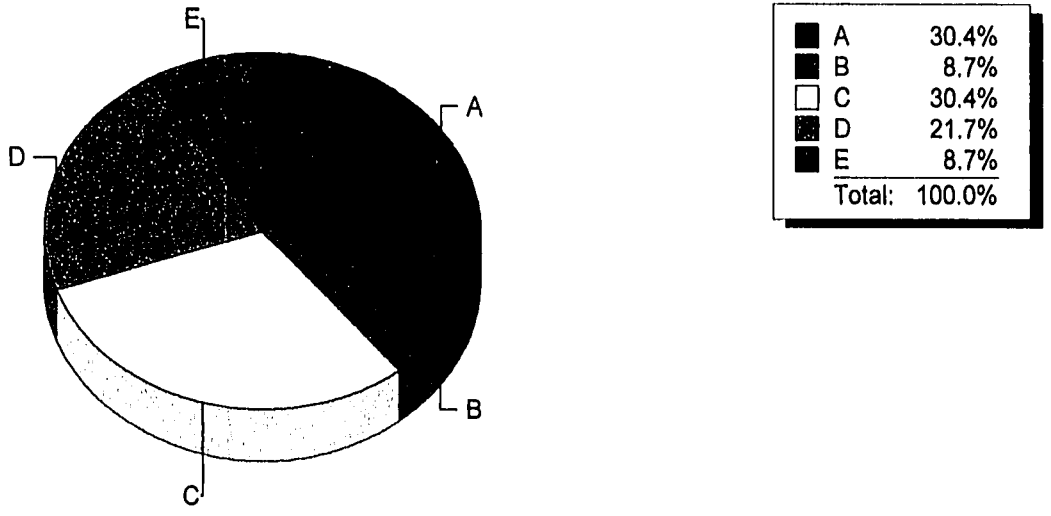
	A	B	C	D	E	Total
Total	**17**	**15**	**23**	**7**	**7**	**69**

Figure 20– Master Builder Definition



	A	B	C	D	E	Total
Total	**10**	**16**	**16**	**2**	**5**	**49**

Figure 21 – "Yes" Respondents Master Builder Definition



	A	B	C	D	E	Total
Total	7	**2**	7	**5**	**2**	**23**

Figure 22 – "No" Respondents Master Builder Definition

Construction and Design Experience

Section IV of the survey asked a series of questions related to construction field experience, designer construction knowledge and design processes. The first question in this section asked if the respondents thought it is important for designers to have construction field experience prior to starting their design careers. The survey results showed that 76.2% of the respondents felt it is important to have construction field experience versus 23.8% that thought it is not important for designers to obtain this type of experience.

The second question in this section asked the respondents whether it was important for designers to learn about construction methods, construction processes, and construction management as part of their formal education. The results showed that 91.7% of the respondents thought that this type of education is important versus 8.3% that felt it was not important.

The third question asked the respondents if designers should be required to obtain construction field experience prior to receiving professional registration. The survey results indicated that 72.6% thought that it is important for designers to receive this type of training prior to being registered and 27.4% thought this type of training was not important prior to registration.

The fourth question in section IV of the survey inquired whether the amount of claims against a design firm's errors and omissions insurance would be reduced if the designer had construction field experience. The results show that 78.6% felt that errors

and omissions insurance would be reduced versus 21.4% that felt errors and omissions would not be reduced.

The second half of Section IV of the survey asked questions related to designer construction education, the construction training that the firms provide employees; factors related to effective construction documents; recommendations for the level of construction experience for designers; on-site construction experience, and how it would enhance design capabilities; and the level of construction experience needed during the education of designers.

The fifth question in Section IV of the survey asked respondents to select the most important factor that contributes to effective construction documents. The most common response to this question was that 45.2% felt architects and engineers with extensive construction experience could produce the most effective documents. The number two response was that allowing the constructor to be involved in the design from conceptualization would produce the most effective documents (21.4%). The third most prevalent response was having the constructor involved after conceptualization to produce the best construction documents (20.2%). The fourth most cited response was architects and engineers with some construction experience would produce the best documents (10.7%). The last response was that architects and engineers with extensive design experience would produce the most effective documents (1.2%). One precent of the respondents did not respond to question number 5 (Figure 23).

The sixth question inquired as to what level of construction experience the respondents would recommend for designers. Sixty-seven percent recommended that

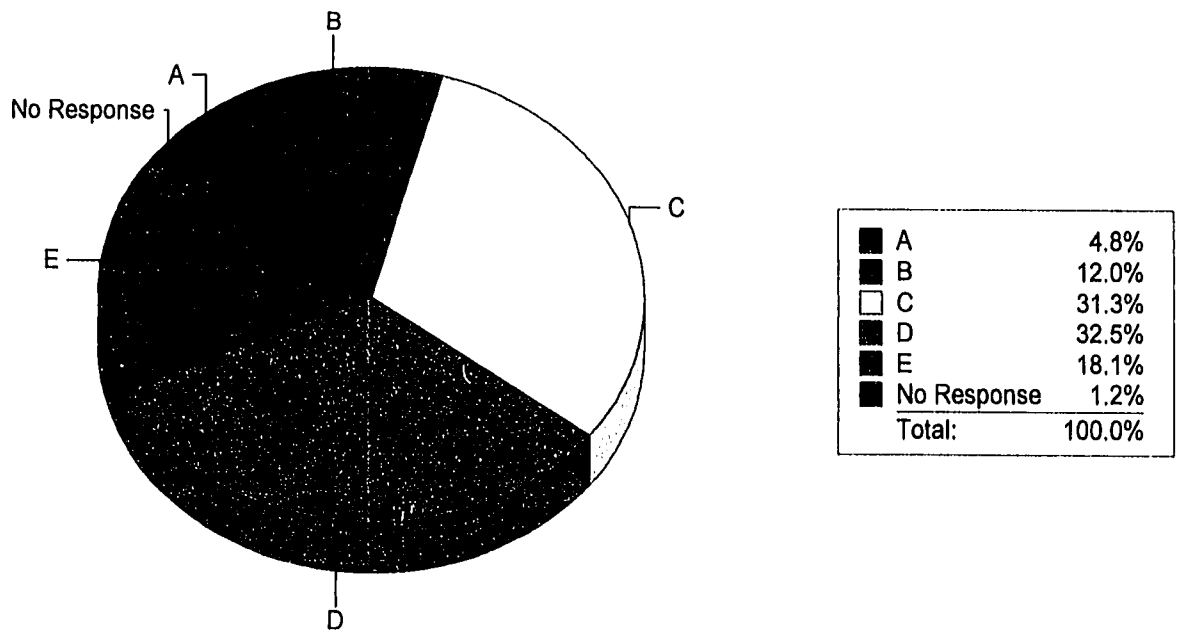
designers receive one to three years of construction field experience. The next most common response was to have designers receive three to five years experience (13.1%) and, 13.1% of the respondents felt that less then one year of experience was needed. The fourth most common response was that no construction field experience was required (3.6%). The fifth most common response was that it is important for designers to have between 3-5 years of construction field experience (1.2%). It was also noted that 2.4% of the respondents did not respond to this question (Figure 24).

The seventh question in Section IV of the survey asked the respondents to provide information about the training programs that are provided by their firms to new employees. The most common response to this question was that 43.4% of the companies do not provide any construction training. The second most common response was that 38.6% felt that their firm held few training sessions and that their firms have no formal construction training programs. The third most common response was that their firms held regular construction seminars and training sessions (10.8%). The fourth most common response was that their firms had an in-house construction training program and they encourage on-going training (2.4%). Five percent of the respondents failed to respond to this question (Figure 25).

The eighth question in section IV of the survey asked the respondents to select the experience level of an on-site construction project observer/participant that would best enhance design capabilities. Fifty percent of the respondents felt that it would be best to have experience on five or more construction projects. The second most common response was that experience on one to five construction projects (44%). The third most

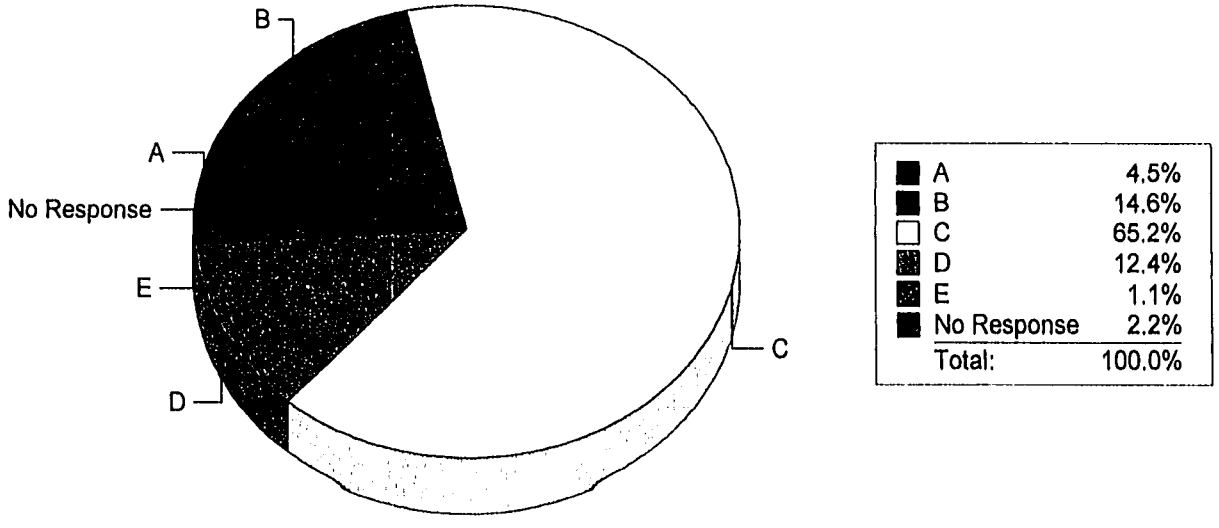
common response was that experience limited to occasional jobsite visits as required (2.4%). The least common response was that no experience was needed (1.2%). Two percent of respondents failed to answer this question (Figure 26).

The ninth and final question of Section IV of the survey requested that the respondents select the level of construction exposure that is important for designers to receive during their education. The most common selection was one to three required courses (45.2%). The second most common response was three or more courses, electives and required courses (21.4%). The third most common response was three or more courses should be required (20.2%). The fourth most common response was no courses (1.2%). One percent of the respondents failed to answer this question.



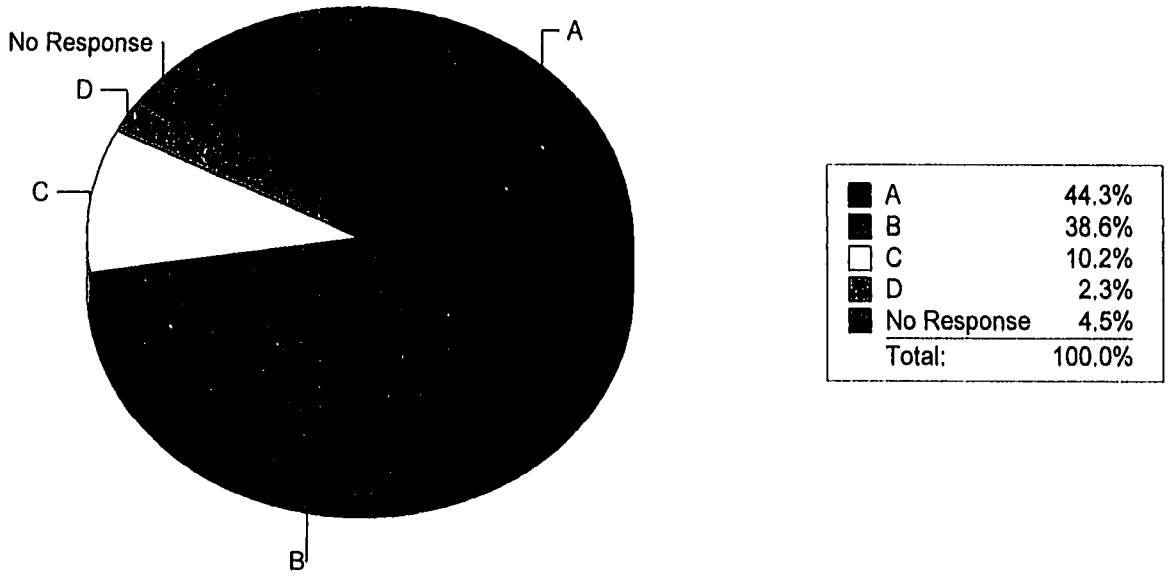
	A	B	C	D	E	No Response	Total
Total	**4**	**10**	**26**	**27**	**15**	**1**	**83**

Figure 23 - Survey Section IV Question #5



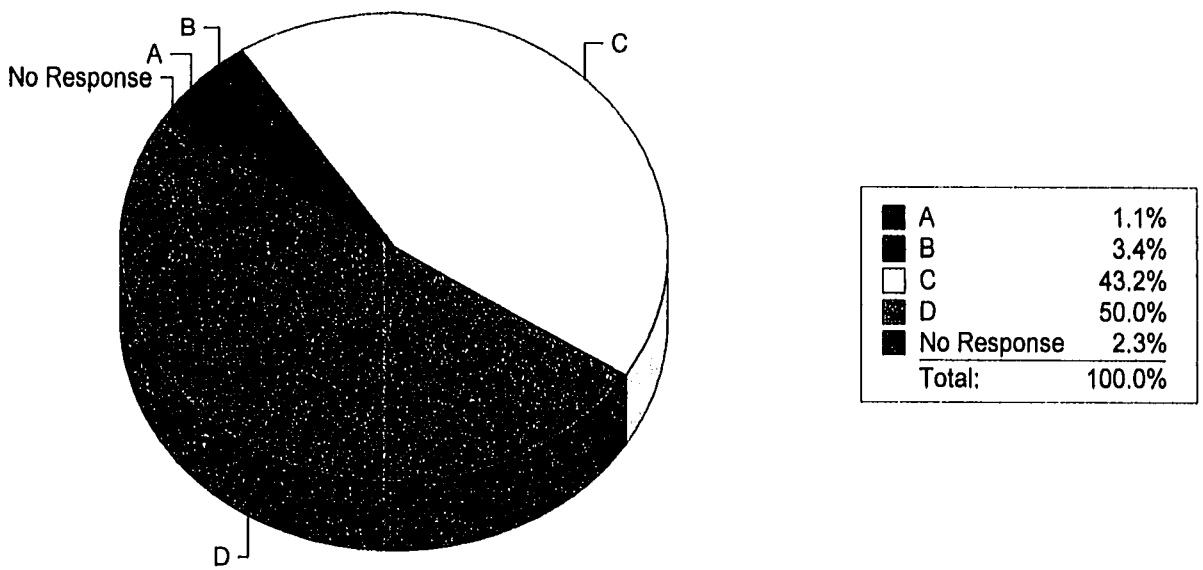
	A	B	C	D	E	No Response	Total
Total	**4**	**13**	**58**	**11**	**1**	**2**	**89**

Figure 24 - Survey Section IV Question #6



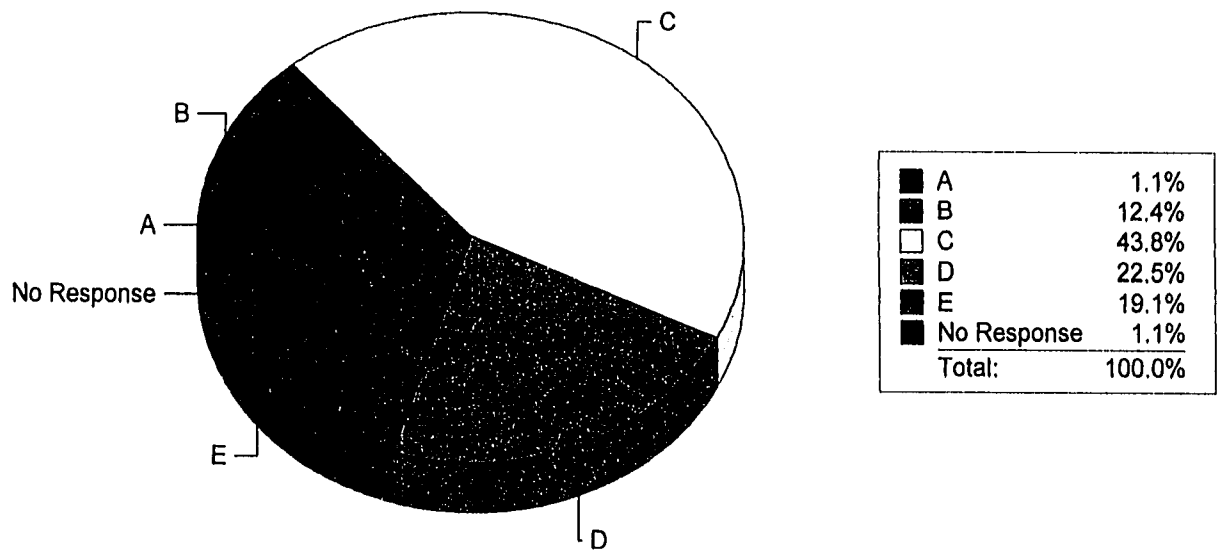
	A	B	C	D	No Response	Total
Total	**39**	**34**	**9**	**2**	**4**	**88**

Figure 25 -Survey Section IV Question #7



	A	B	C	D	No Response	**Total**
Total	**1**	**3**	**38**	**44**	**2**	**88**

Figure 26 -Survey Section IV Question #8



	A	B	C	D	E	No Response	Total
Total	**1**	**11**	**39**	**20**	**17**	**1**	**89**

Figure 27 -Survey Section IV Question #9

CHAPTER 5 SURVEY ANALYSIS

This chapter contains an analysis of the results that were obtained from the research.

Training Programs

One part of the survey used for this research project addressed the use of training programs and their use within architecture, engineering and construction (A/E/C) firms. This section explored the importance of training activities as indicated by the level of responsibility managers of A/E/C firms have towards their employees and how firms encourage additional knowledge acquisition. The survey provided questions to help determine the importance of construction knowledge for design engineers and architects.

The survey results showed that only 22.5% of the members of the firms participating in this research survey have training programs. Of the firms that do not do design work (contractors, construction managers, other and owner/property managers) 22.9% have formal training programs and of the design firms (architects, engineers and multiple design) 22.2% have formal training programs. However, the survey results also indicated a correlation coefficient of 0.99 and a coefficient of determination of 0.99 that indicated that both the design and non-design firms use formal training methods in similar proportions.

The survey results indicated that 55% of all firms utilize "on-the-job" training programs and 48.6% of the non-design firms and 40.7% of the design firms employ this training method. This 7.9% difference is significant in that design firms utilized this

method at a rate less then non-design firms. It is also significant that the overall rate of "on-the-job training" of 55% is twice the formal training rate for all respondents. This large difference can be related to one of the respondent's comments:

> " Currently the colleges/universities provide the background education concepts, how to think like an engineer, basic sciences and materials technology. The student pays for this education. The firms provide more practical knowledge - how to prepare calculations and design documents, construction field experience. The firms pay for this, but often the individual doesn't stay with the firm long enough to allow the firm to recap the cost of education. Either the student must pay more for the education (shift some of the practical training to the schools) or the firm's fee must be increased to pay for this training. For smaller firms that feel they cannot set up formal training, consider training set up jointly by several firms perhaps utilizing a professional organization or local college/university. This might be especially valuable for construction field training ".

Many of the respondents felt that their firms do not provide enough formal and on-the-job training. Evidence of this is shown by the numerous comments provided in the surveys. Listed below are several comments from respondents related to the training programs used by their firms.

> "Yes , it is way better to have construction/on-site experience, as much as possible, but you are lucky or not if you get it. It should not be obligatory."

> "Mentoring, mentoring and mentoring"

> "I think designers should learn about architecture during school. Drafting and construction after graduation or during intern years at an architecture firm. Most large firms will not give you that and only a select few small/medium size firms will provide that education. Probably best for architecture students to work construction for a few years prior to working as a designer."

> "I think you are right about field experience but, how to find time to allow everyone to participate is the trick. Maybe courses that involve credit for apprenticeship, while at school, with local firms."

"No formal on the job training is provided, catch as catch can."

"Sink or swim mentality"

The respondents were also asked to provide information about specific areas of training, both formal and "on the job", and these areas included constructability, construction methods, construction materials, construction management, and design. The surveys revealed that for firms using formal training methods the non-design firms used formal training methods more frequently then design firms (1.15 to 3.09 times more often see Figure 28). However, design firms used "on-the-job training methods more frequently then non-design firms, from 1.1 to 10 times more frequently (Figure 29). Combining the two training types reveals that design firms provide training more frequently then non-design firms. In most cases design firms provided training at rate of two times more than non-design firms. Combining both types of training indicated that design firms train their personnel more frequently in the areas of constructability, construction methods, construction materials and design from 1.35 to 4.67 more frequently then non-design firms. However, non-design firms train their employees in the area of construction management at 1.29 times the rate for design firms.

Additionally, these distribution results were subjected to a correlation analysis using Pearson's product moment correlation (r), the coefficient of determination (r-squared or RSQ) and the level of statistical significance tests. The results for the different types of formal training showed an r-value of 0.658 and a RSQ of 0.433. These results indicated a strong correlation, a high RSQ value, and statistical significance. Which indicated that both designers and non-designers use formal training methods in a

similar manner. However, these tests produced dramatically different results when used with the "on-the-job" training results. The r-value for the "on-the-job" training is 0.146 and the RSQ is .021. Which indicated that the "on the job" training results show a very low correlation, a weak RSQ, and little statistical significance.

This indicated that design firms have a much stronger "on-the-job" training methodology and non-design type firms tend to provide more formal training programs. It was also evident that these two types of firms use formal training methods in a similar manner and proportion but there is minimal commonality for "on the job" training methods. However, design firms provide more training opportunities for their employees.

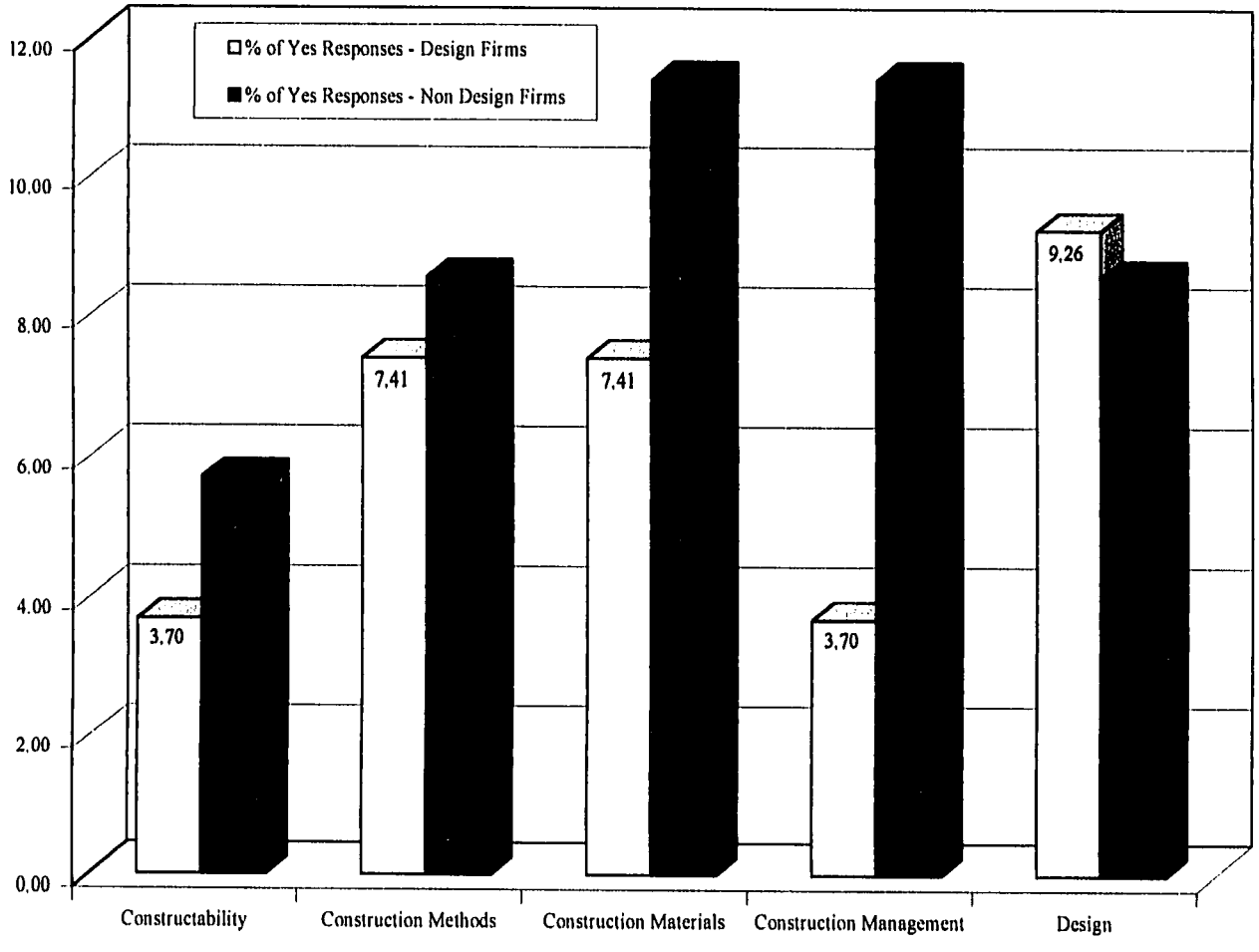


Figure 28 - Formal Training Programs by Training and Firm Type

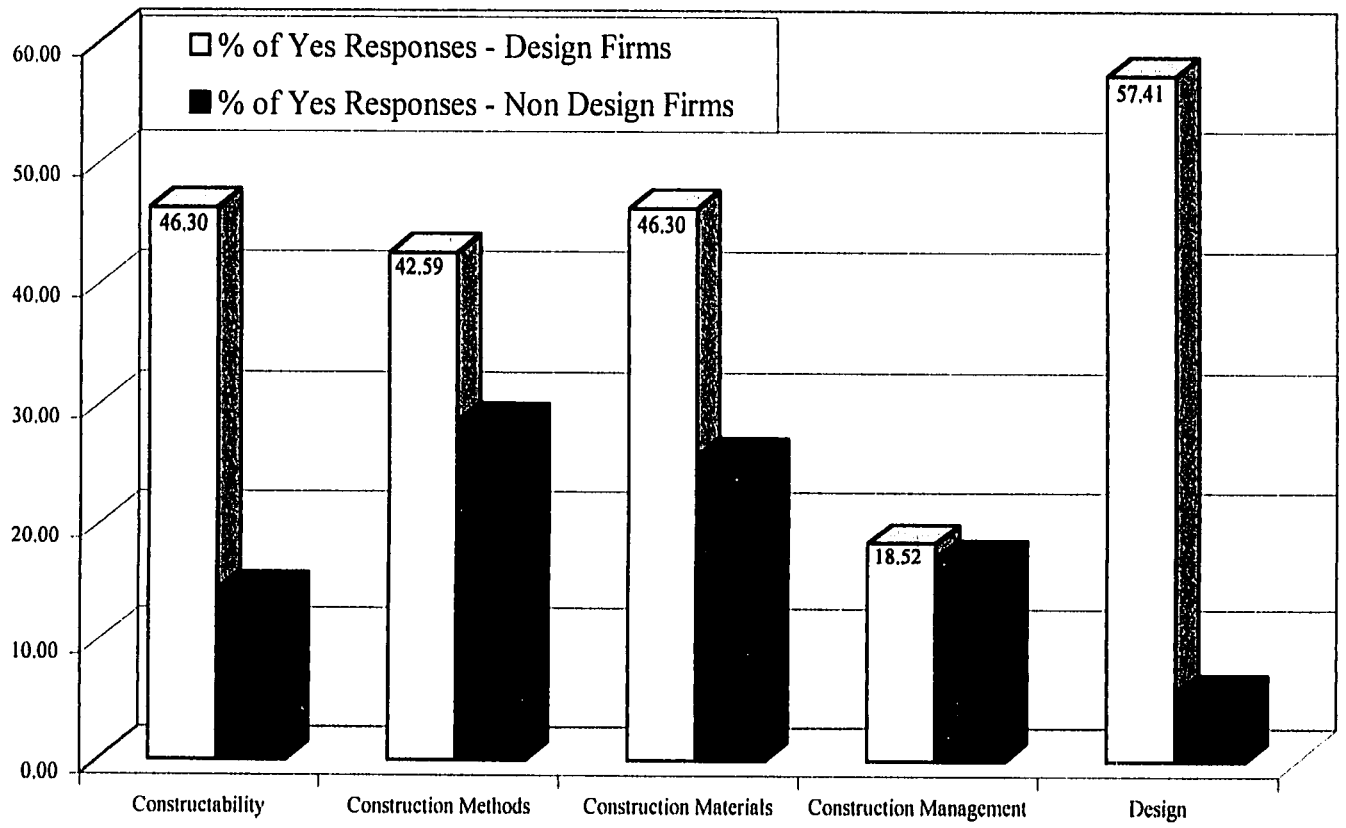


Figure 29 – "On the Job" Training Programs by Training and Firm Type

Professional and Trade Organizations

The importance of an individual's membership and participation in professional and trade organizations provides the level of importance designers and non-designers place on staying current with industry trends and new technology. It is important to identify the relationship between design and non-design firms responses related to participation levels.

The survey reveals that non-designers were 1.7 times more likely to not join professional organizations. However, non-designers had a higher rate of joining one professional organization then designers (26% versus 20%) also non-designers joined more then 2 or more professional organizations at a rate of 1.57 times less then designers. An inverse situation occurs when membership rates are compared for trade organizations. Design professionals were almost 3 times less likely to belong to a trade organization. Additionally, designers were 4.23 times less likely to belong to one or more trade organizations. These results indicate a much larger percentage of non-designers joining professional organizations then designers joining trade organizations.

Additionally, the distribution results were subjected to a correlation analysis using product moment correlation, coefficient of determination, and the level of statistical significance. The results for the membership in professional organizations showed an r-value of 0.066 and a RSQ of 0.004. These results indicate a very weak correlation, an extremely low RSQ value, and little statistical significance. Additionally, the r-value for trade organization membership is 0.194 and the RSQ is .04. This shows a very low correlation, a weak RSQ, and little statistical significance. These types of correlation

results should be expected because designers tend to join professional organizations and non-designers would tend to join trade organizations.

The differences in membership are also reflected in the rate at which designers and non-designers attend professional and trade seminars. The survey results showed that non-designers had a rate of 2.18 times higher for not attending professional seminars than designers. In contrast, non-designers had a rate of attending at least one seminar 2.5 times higher than designers and nearly equal rates of attendance for 1 to 3 and 3 to 5 professional seminars over a three year period. Designers attended 5 or more seminars at a rate 3.11 times higher then non-designers. Additionally, designers had a 1.95 times higher rate of not attending any trade seminars then non-designers. Both designers and non-designers had equal rates of attending at least one trade seminar.

Designers were slightly more than 2 times less likely to attend 1-3 trade seminars and nearly equal in attending 3-5 trade seminars, or more, over a three year period. These results showed a greater tendency of non-designers to be interested in the work of designers then designers being interested in non-designers work. This trend further supports the theory that designers are less likely to acquire construction knowledge then their non-design counterparts in the construction industry. However, it also supports the idea that non-designers are more interested in design issues then designers are interested in construction issues. Additionally, a correlation analysis using product moment correlation, coefficient of determination, and the level of statistical significance was performed on the professional and trade organization seminar distribution and the results for the attendance of professional seminars showed an r-value of 0.579 and a RSQ of

0.336. These results indicate a moderate correlation, an intermediate RSQ value and statistical significance. Additionally, the r-value for trade organization seminar attendance is 0.402 and the RSQ is 0.161. These trade organization correlation results showed a moderate level of correlation, an intermediate RSQ, and statistical significance. These types of correlation results showed that designers and non-designers attend trade and professional seminars in similar proportions and frequency.

However, the overall results still indicate that high numbers of designers and non-designers do not use this method for obtaining knowledge. Because designers are less likely to participate in trade organizations it provides support to the hypothesis that designers do not consider construction training as important, or required, to produce good designs.

Jobsite Visits

The survey revealed that both designers and non-designers have a strong requirement/obligation to visit jobsites as part of their work. Overall, only 5 respondents out of 89 did not work for companies that encouraged them to visit jobsites. This process does not guarantee that designers are learning construction techniques, or processes, to augment their design training. The survey asked respondents to identify standard activities that they performed when visiting jobsites. The survey revealed that designers most commonly performed tasks, highest to lowest, such as (Figure 30):

- Documenting activities (83%)
- Resolving constructability issues (81%)
- Resolving plan and specification conflicts (63%)
- Observing unique construction (61%)
- Working on punch lists (57%)

- Planning and coordination (44%)
- Inspections and change order processing (43%)
- Assisting others (35%)
- Contract compliance (33%)
- Scheduling (24%)
- Estimating (9%)
- Safety issues (7%)

Two of the three highest responses indicated that designers are spending a higher percentage of their time at the jobsite resolving issues related to their designs. It is interesting to note that the three lowest designer responses scheduling, estimating and safety are issues that non-designers perform at a much higher rate (Figure 30). Another interesting result is that designers had a high of 83% for documentation to a low of 7% for safety, while non-designers had a high of 54% for constructability, planning and coordination and estimating to a low of 28% for documentation (Figure 30). This indicates that non-designers spend more time equally on all items while designers concentrated on fewer areas.

Correlation analysis of the jobsite visit results revealed that both designers and non-designers have an r-value of 1.00 and an RSQ of 1.00. This indicated a very high correlation, very high-shared variance, and statistical significance. This shows that designers and non-designers consider jobsite visits to be an important part of their assignments. Correlation analysis of the types of activities that are performed during jobsite visits by designers and non-designers revealed an r-value of –0.119 and an RSQ of 0.014, which showed a low correlation, a low-shared variance and no statistical significance. These correlation results show that both designers and non-designers find jobsite visits important, but perform dramatically different functions during these visits.

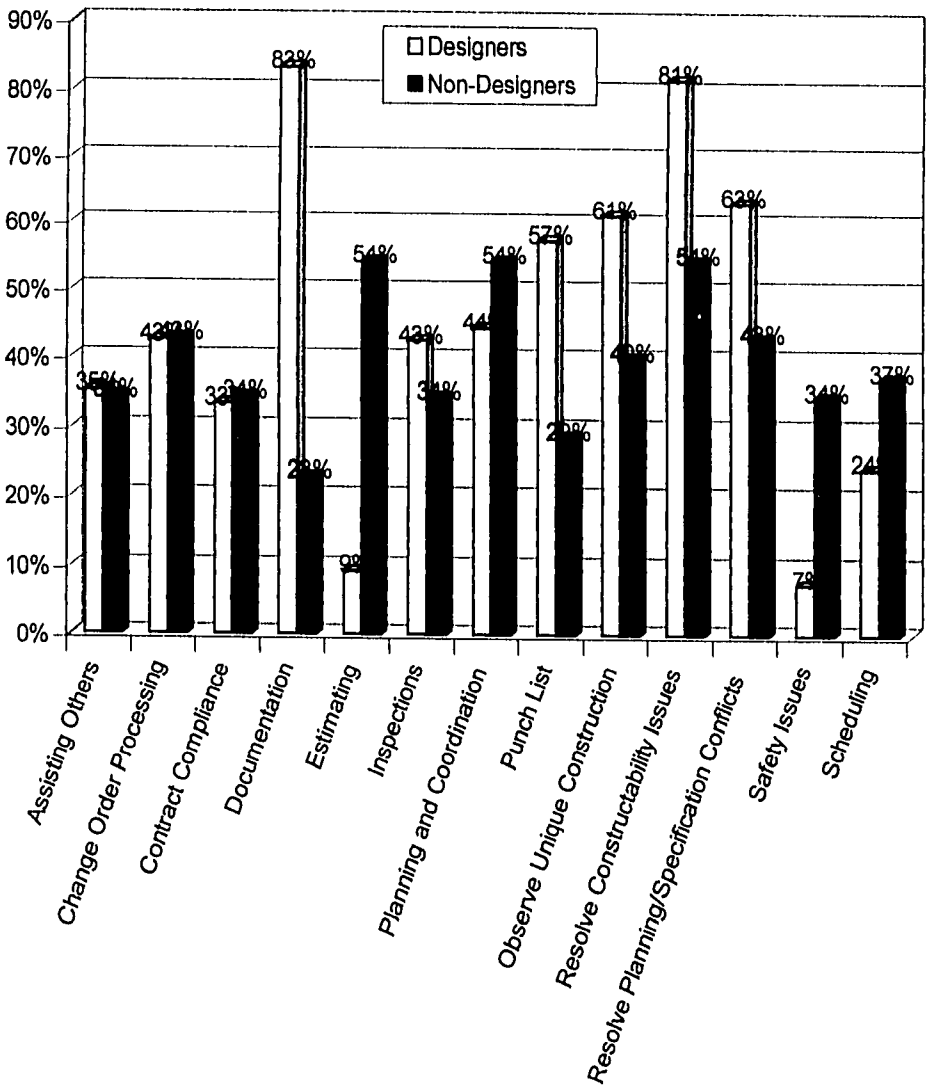


Figure 30 – Jobsite Visits Job Functions Performed

Project Delivery System Participation

The survey requested participants to identify the different types of project delivery systems they have been involved with on construction projects. The results obtained from this question show that the designers and non-designers have both participated in Design/Build and Design/Bid/Build project delivery systems at relatively equal rates, 72% for designers versus 68.5% for non-designers for Design/Build and 76% for designers and 80% for non-designers for Design/Bid/Build type projects (Figure 31). These results are significant in that these project delivery systems tend to provide designers with greater access to construction input during the design phase. The survey requested the respondents to list their preferred project delivery system. The results obtained for this question indicated that designers and non-designers preferred the Design/Bid/Build (Negotiated) method. Over 50% of the non-designers and 40% of the designers preferred this delivery system method. However, 25.93% of the designers and 14.29% of the non-designers indicated that they had no preference of one system over another. Eighteen percent of the designers and 11.43% of the non-designers were not sure if they had a preference. All other project delivery systems were indicated by less then 12% with most of the remaining systems receiving less than 6% of the responses (Figure 32).

Additionally, the distribution results were analyzed using the correlation analysis with product moment correlations, coefficients of determination, and the level of statistical significance tests. The results for delivery system participation showed an r-value of 0.925 and a RSQ of 0.856, which indicated a strong correlation, an extremely

high-shared variance, and high statistical significance. Additionally, the r-value for delivery system preference was 0.859 and the RSQ was 0.739, which indicated that these results showed a high correlation, moderate shared variance or RSQ and statistical significance.

The results obtained indicated a preference by both designers and non-designers to work in collaborative project delivery systems and an indication that designers prefer to have contractor input into their designs. This supports the research hypothesis that designers should obtain construction knowledge to improve designs.

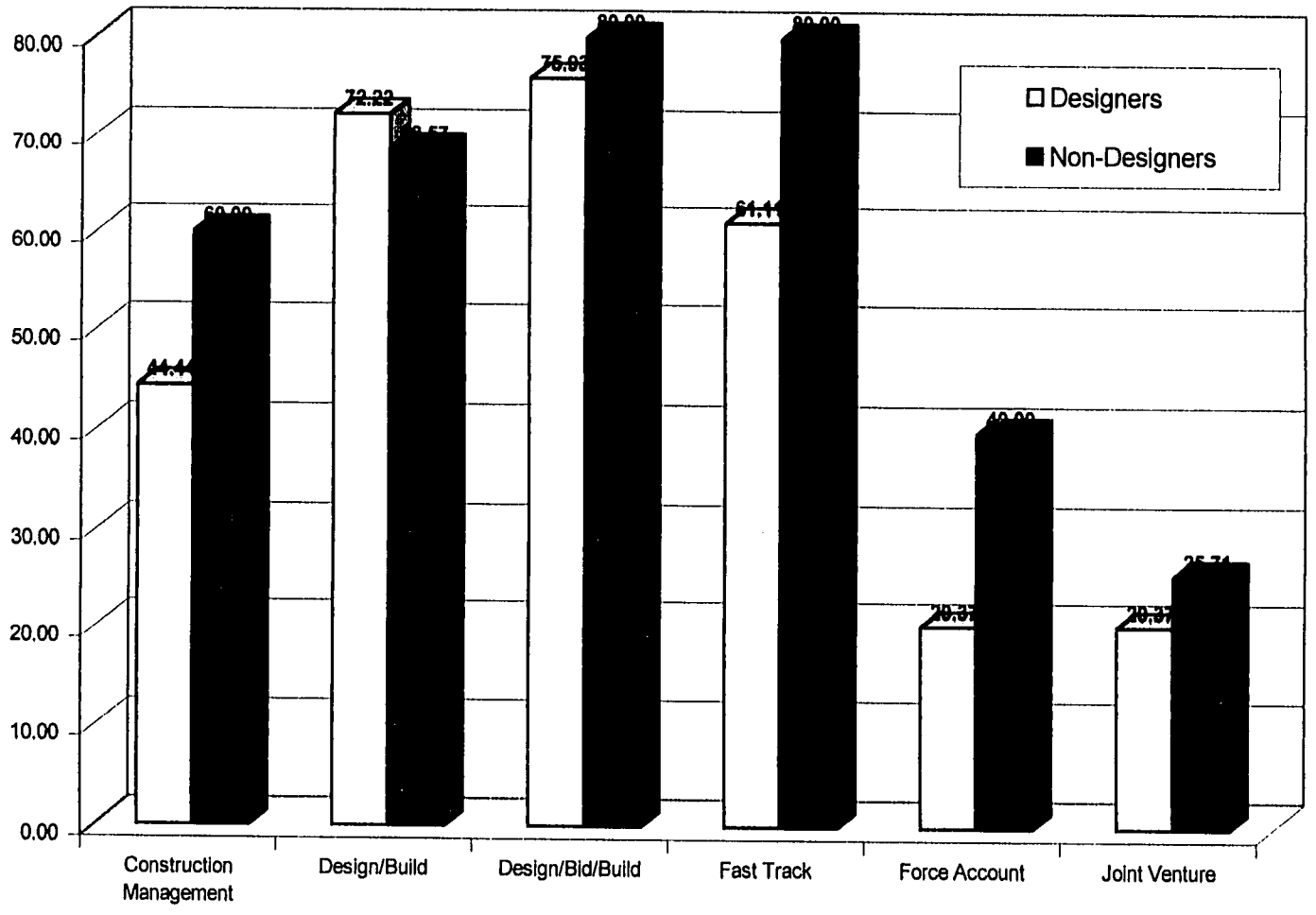


Figure 31 – Project Delivery Preference

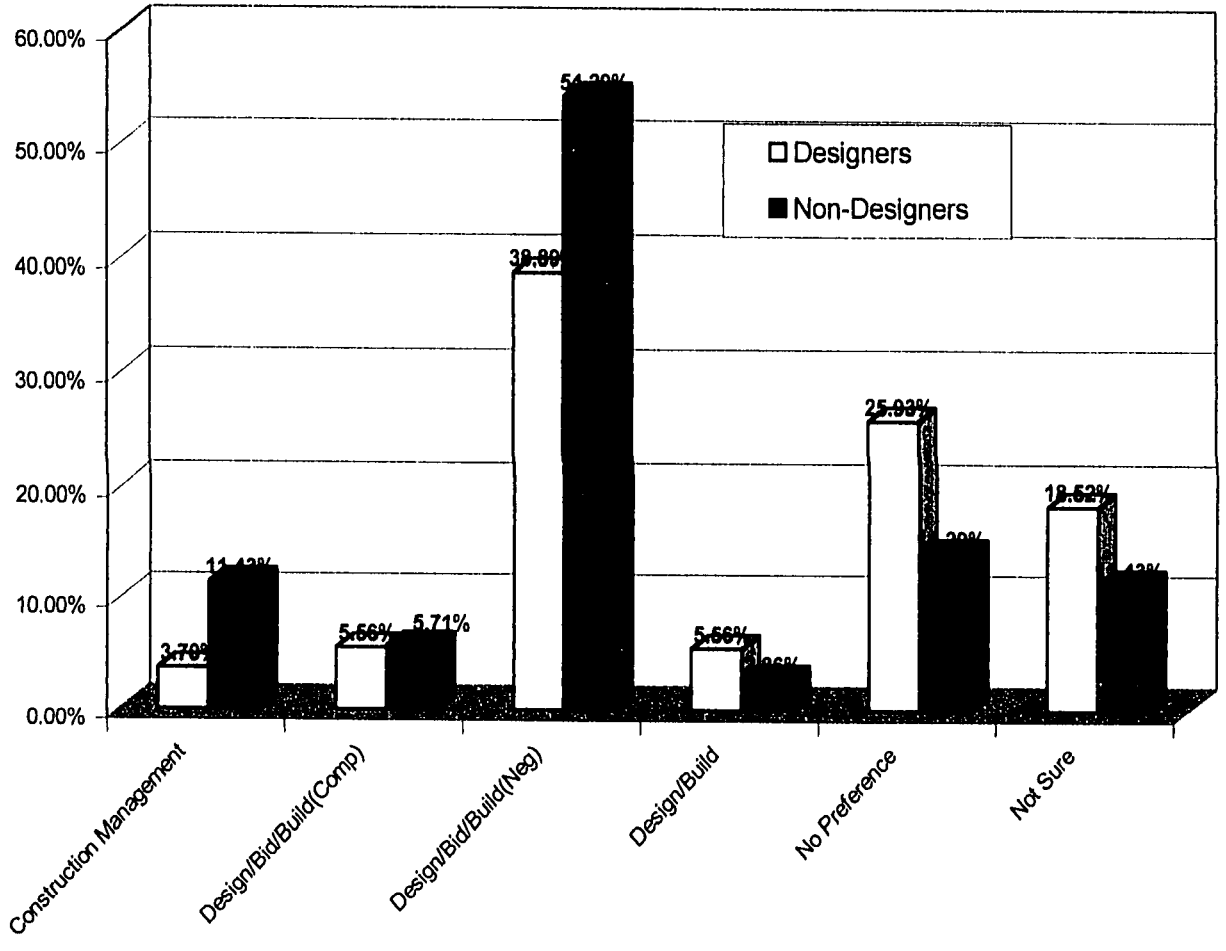


Figure 32 – Project Delivery System Exposure

Master Builder Term and Definition

The survey also requested respondents to answer the question of whether they were familiar with the term "Master Builder" and the definition of the "Master Builder". The survey results indicated that 63% of the designers and 49% of the non-designers were familiar with the term "Master Builder"(Figure 33).

The results also revealed that 24% of the designers and 25% of the non-designers indicated the term "Master Builder" is "A project delivery system that includes all parties involved in a construction project from concept to operation". Thirty-six percent of the designers and 7% of the non-designers indicated the term "Master Builder" is "An old construction industry term that is no longer applicable to the construction industry". Twenty-seven percent of the designers and 39% of the non-designers indicated the term "Master Builder" is "Design firms with Architects or Engineers highly trained and educated that have extensive knowledge of both design and construction that also provides construction services." Seven percent of the designers and 14% of the non-designers indicated the term "Master Builder" is "Contractors that employ designers to handle all phases of a project from concept to operation". Fourteen percent of designers, and 7% of the non-designers, indicated the term "Master Builder" is " Construction and Design firms that perform projects via the Design/Build project delivery system" (Figure 34).

The distribution results were subjected to a correlation analysis using product moment correlations, the coefficient of determination or shared variance, and the level of statistical significance. The results obtained for the question on the definitions of

"Master Builder" showed an r-value of 0.16 and a RSQ of 0.026. This indicated a very weak correlation, and an extremely weak shared variance and statistical significance.

The correlation analysis indicated that designers and non-designers do not agree on the definition of "Master Builders". Additionally, the results indicated that designers clearly think that the term Master Builder is not as relevant to the current construction industry (36% indicated that the term is no longer applicable) and more non-designers were able to properly define the term Master Builder (39% indicated that the term means highly trained and educated Architects and Engineers that perform construction services).

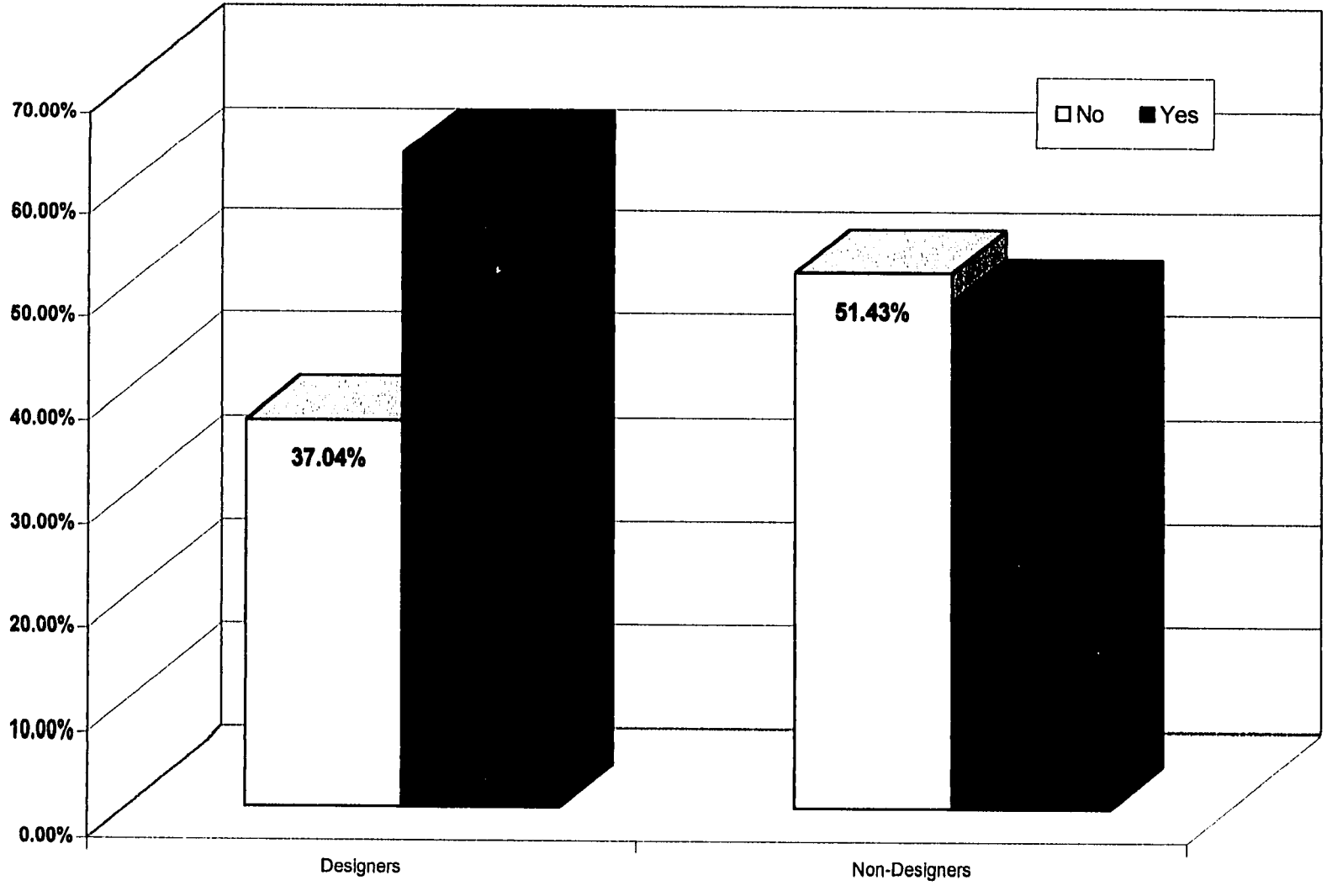


Figure 33 – Master Builder Identification by Respondent Type

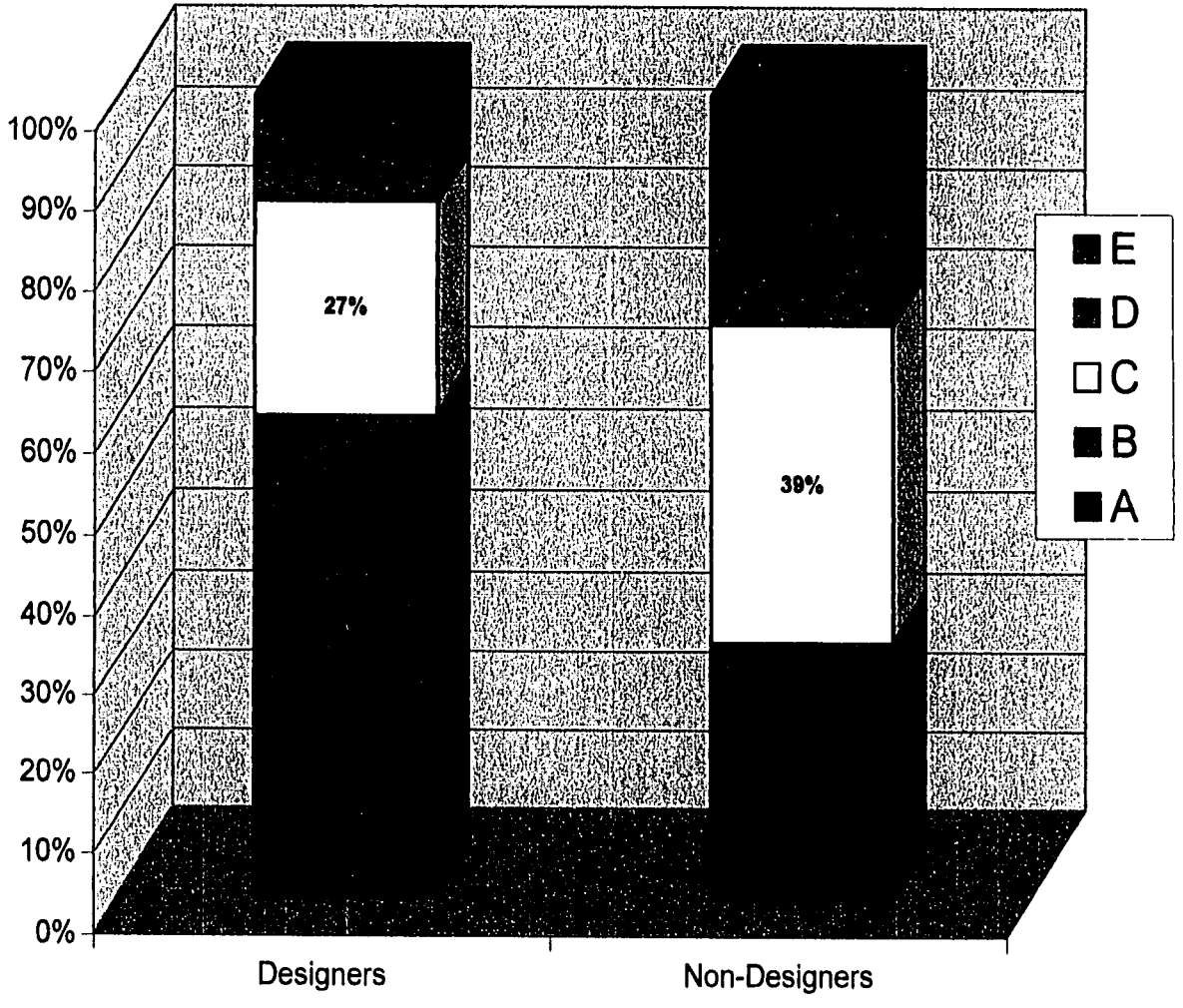


Figure 34 – Master Builder Definition by Respondent Type

Construction Experience and Design

The fourth section of the survey requested information about the construction and design experience of the respondents and how they relate to one another. The first question asked, " Do you think it is important for designers to have construction field experience prior to starting their design careers"; the second question inquired as to whether " designers should be required to also learn about construction methods, processes and construction management as part of their formal education"; the third question was on whether " Designers should be required to obtain construction field experience prior to receiving professional registration"; the fourth question was " Do you think that claims against a design firm's errors and omissions insurance would be reduced if designers had construction field experience."

Over two-thirds of both the designers and the non-designers felt that it is important for designers to have construction field experience, and learn about construction methods and materials prior to obtaining their registration. Over 75% of the non-designers responded yes to these four questions in section four of the survey (Figure 35). The results indicated a need for designers to receive construction training prior to starting the design phase of their careers. Designers also need to learn about construction methods, processes, and construction management during their education. The respondents also indicated that designers should also have construction field experience prior to professional registration and that errors and omissions insurance claims could be reduced if more construction field training was provided to designers.

Questions 1-4 in Section IV were combined and entered into a spreadsheet and analyzed for any correlations among the data. The correlations for questions 1-4 showed an r-value of 0.786 and a RSQ or shared variance of 0.617. This indicated a strong correlation, a high-shared variance, and a high statistical significance between designers and non-designers responses to these four questions.

The respondents were also prompted to identify the most important factor that they think contributes to effective construction documents. The survey results showed that 41.7% of the designers selected "Architects and Engineers with extensive construction experience". For the non-designers 17.7% selected this option; however, 53% of the non-designers and 18.75% of the designers selected "Allowing the constructor to be involved in the design phase from conceptualization" (Figure 36).

The correlation results reveled an r-value of 0.18 and an RSQ of 0.032, which indicated a low correlation, low common variance, and little statistical significance between the responses from designers and non-designers. This indicated that designers would prefer a "Master Builder" type delivery system and that non-designers would support the design/bid/build (Negotiated) type delivery system.

The survey also asked the respondents to identify the level of construction experience that designers should have to produce effective construction documents. Over 60% of the designers felt 1-3 years of construction experience would be appropriate and over 74% of the non-designers also indicated this level of experience. Over 17% of the non-designers felt that 3-5 years would be an adequate amount of training and over 19% of the designers felt less then 1 year would be adequate. The correlation results showed

an r-value of 0.968 and an RSQ of 0.937 which indicated that the designers and the non-designers responses had a high correlation, high-shared variance, and high statistical significance. These results indicated that the respondents felt that 1-3 years of construction experience would be needed to produce effective design documents (Figure 37).

Question number 7 in Section four asked the respondents to rank the level of construction training that is being provided by their firms. The responses indicated that more then 80% of design and non-design firms provide limited training and have no formal training programs. Thirty-seven percent of the design respondents and 61% of the non-design respondents had no training programs (Figure 38). The correlation analysis for this question resulted in an r-value of 0.754 and an RSQ of 0.568, which indicated a high correlation, a high-shared variance, and high statistical significance. This means that members of both design and non-design firm's feel construction training is a low priority, or they do not have the resources to provide this type of training.

Question number 8 in Section IV asked the respondents to select the experience level of an on-site construction project observer/participant that would enhance the design capabilities of a designer. Over 40% of both the designers and the non-designers felt experience on 1-5 projects would be beneficial. Over 50% of both designers and non-designers felt 5 or more projects would be appropriate (Figure 39). The correlation analysis resulted in an r-value of 0.99 and a RSQ of 0.981, which indicated a high correlation, a high-shared variance and high statistical significance. The results mean that designers and non-designers both agreed that designers would benefit from on-site

observation and participation. This supports the hypothesis that designers would benefit from construction field experience prior to starting their design careers.

The final question of Section four asked the respondents to identify the amount of construction exposure that students should have during school. Forty-Six percent of the designers and forty-one percent of the non-designers indicated that 1-3 courses are adequate, but the respondents felt these should be required courses. Twenty percent of the designers and twenty-six percent of the non-designers thought students should have 3 or more courses and these courses could be a mix of electives and required courses (Figure 40). Additionally, the correlation analysis for this question resulted in an r-value of 0.855 and a high RSQ value of 0.731, which indicated a high correlation, a high-shared variance and high statistical significance. The results obtained indicated that industry professionals prefer students who have had more than just minimal exposure to construction concepts during their college education.

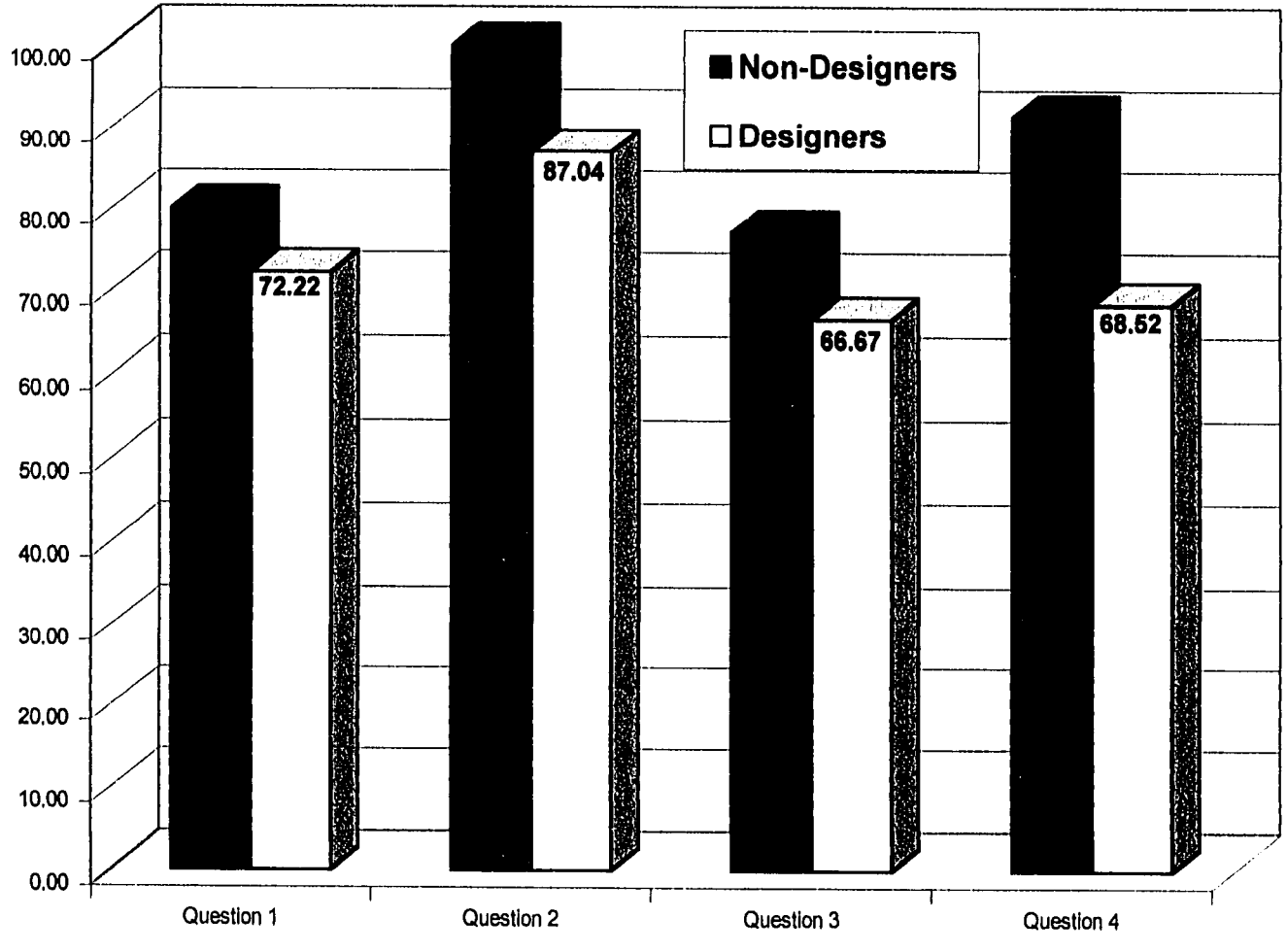
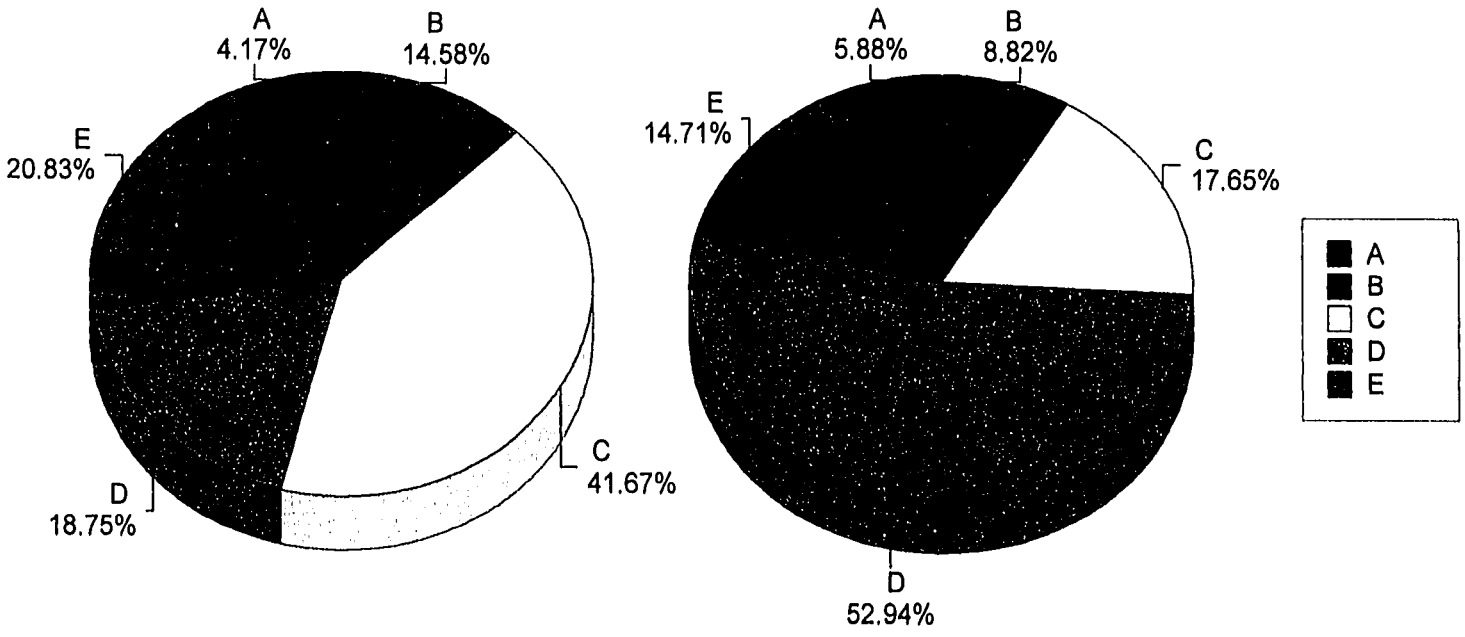
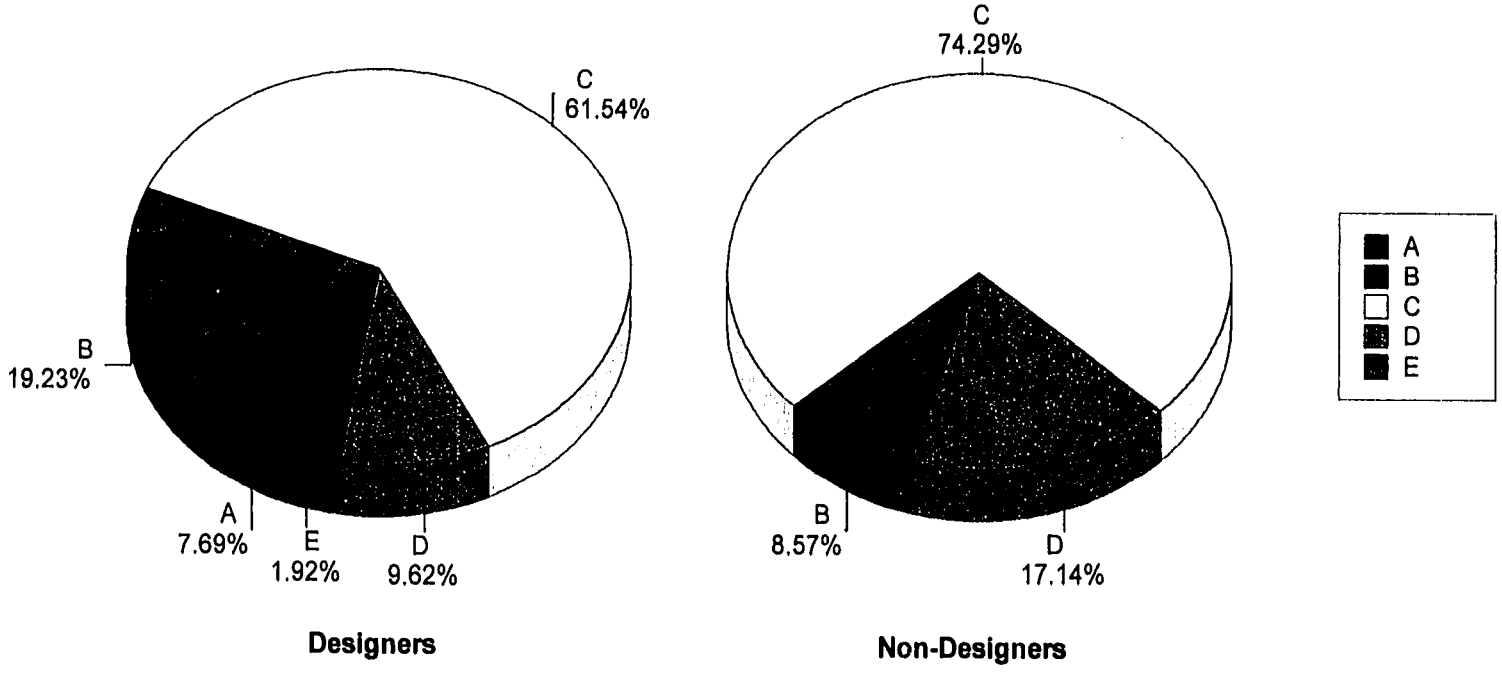


Figure 35 – Survey Section IV Questions #1-4 by Respondent Type



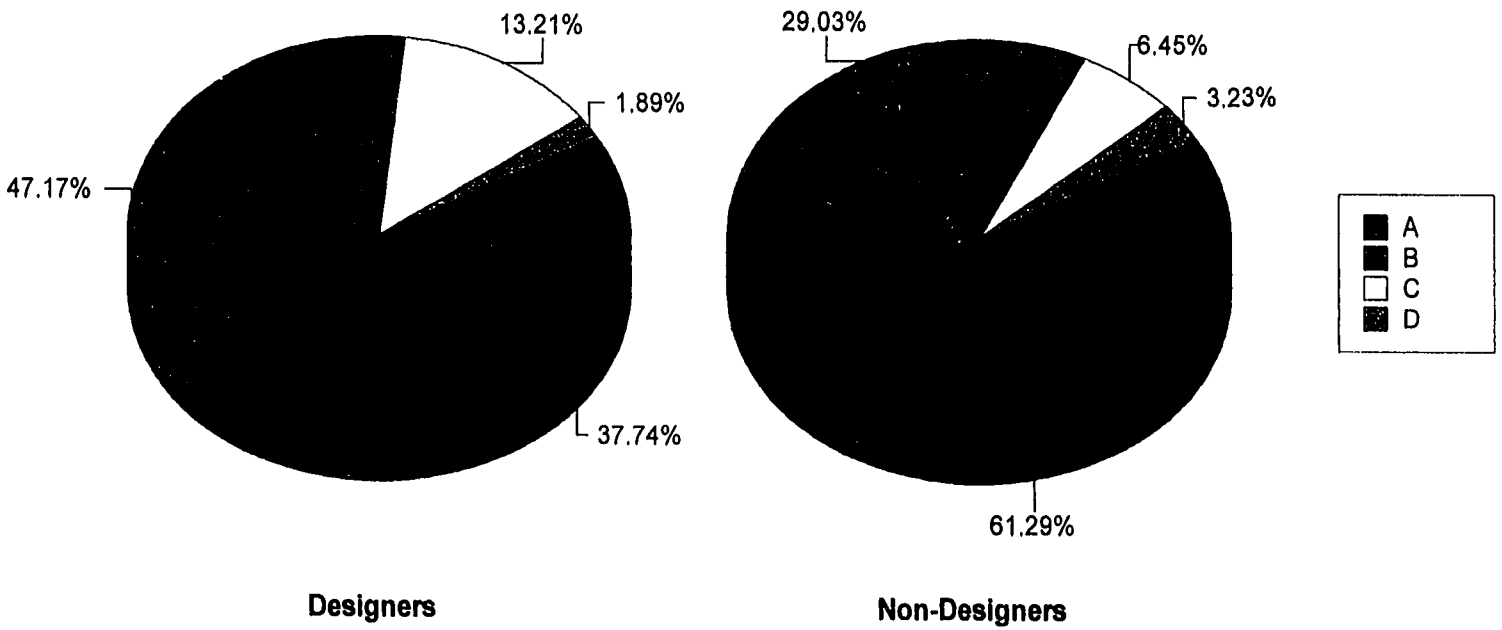
	A	B	C	D	E	Total
Designers	**2**	**7**	**20**	**9**	**10**	**48**
Non-Designers	**2**	**3**	**6**	**18**	**5**	**34**
Total	**4**	**10**	**26**	**27**	**15**	**82**

Figure 36 – Survey Section IV Questions #5 by Respondent Type



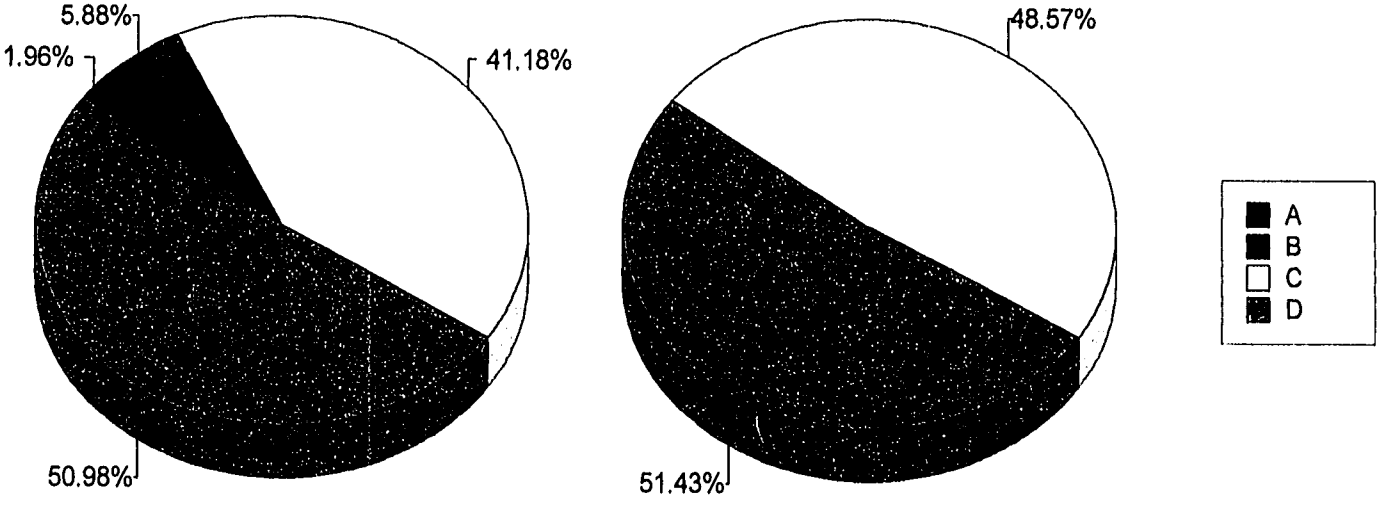
	A	B	C	D	E	Total
Designers	**4**	**10**	**32**	**5**	**1**	**52**
Non-Designers	**0**	**3**	**26**	**6**	**0**	**35**
Total	**4**	**13**	**58**	**11**	**1**	**87**

Figure 37 – Survey Section IV Questions #7 by Respondent Type



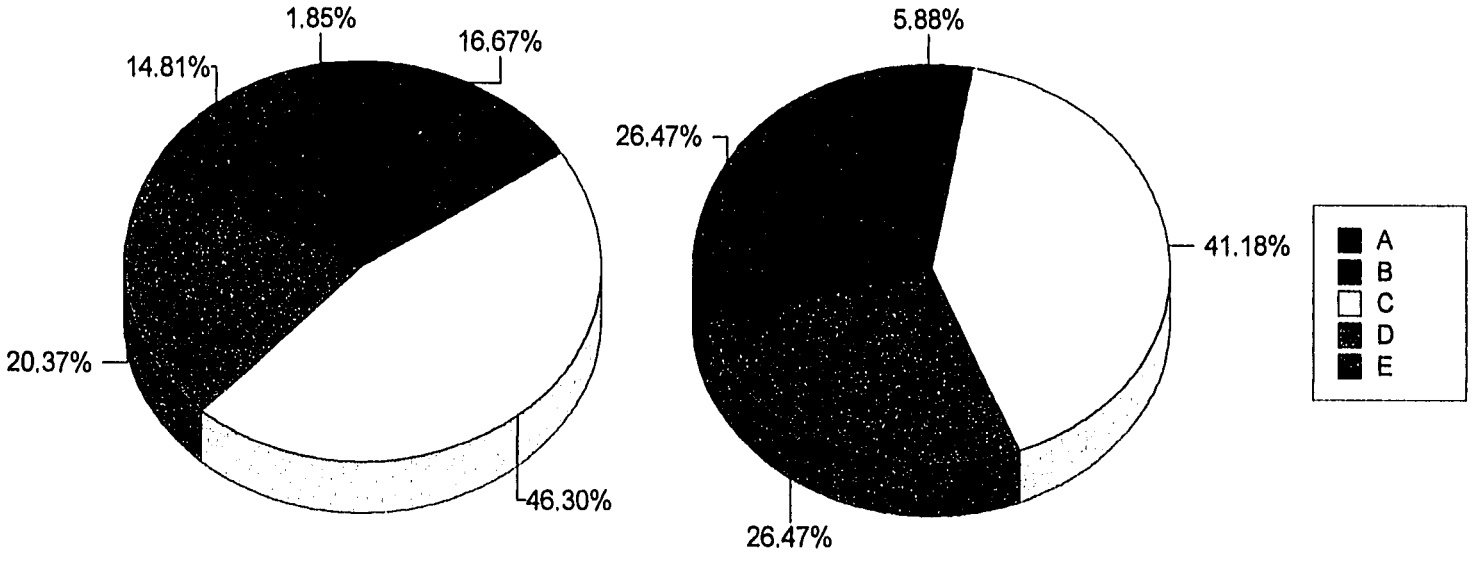
	A	B	C	D	Total
Designers	**20**	**25**	**7**	**1**	**53**
Non-Designers	**19**	**9**	**2**	**1**	**31**
Total	**39**	**34**	**9**	**2**	**84**

Figure 38 – Survey Section IV Questions #7 by Respondent Type



	A	B	C	D	Total
Designers	**1**	**3**	**21**	**26**	**51**
Non-Designers	**0**	**0**	**17**	**18**	**35**
Total	**1**	**3**	**38**	**44**	**86**

Figure 39 – Survey Section IV Questions #8 by Respondent Type



	A	B	C	D	E	Total
Designers	**1**	**9**	**25**	**11**	**8**	**54**
Non-Designers	**0**	**2**	**14**	**9**	**9**	**34**
Total	**1**	**11**	**39**	**20**	**17**	**88**

Figure 40 – Survey Section IV Questions #9 by Respondent Type

CHAPTER 6 CONCLUSIONS

Conclusions

This thesis includes sections on the U.S. construction industry history, research methodologies, a literature review of relevant construction industry publications, results from a survey of construction industry professionals about designer construction knowledge, an analysis of the survey results including statistical information, conclusions based on the survey results, analysis and literature review, and recommendations based on the survey results, analysis, literature review and conclusions.

The survey results, and an analysis of the results, indicated that a large percentage of the respondents feel designer construction knowledge, which is obtained prior to starting a design career, is important. The results also indicated that many of the respondents did not think that design firms provide enough training for their employees and that many engineering and construction professionals are not members of professional, or trade organizations, which limits their opportunities for staying current with industry trends and their access to a source of construction training.

Personnel from A/E/C firms universally support, and require, visit to jobsites, which indicates that designers have some opportunities for acquiring construction training and knowledge. Jobsite visits do not ensure that designers will receive, or acquire, appropriate training. The survey results indicated that designers tend to perform tasks at the jobsites related to resolution of design problem rather than obtaining construction knowledge.

The survey also revealed that many respondents have been involved with a wide variety of different project delivery type that suggests that designers are familiar with the

different project delivery methods. However many respondents, especially designers (37%), were not familiar with the term "Master Builder" and even if they were familiar with the term they could not properly define its meaning. These results seem to indicate a lack of knowledge regarding the term "Master Builder" and this may indicate that its meaning will rapidly change, i.e.: design-build, or completely disappear from the A/E/C industry.

Finally, the survey and the research results obtained from the A/E/C industry members supports the hypothesis of the necessity for designers to receive construction training prior to starting their design careers. Also, designers and non-designers felt that errors and omissions insurance would be reduced if designers received construction training. The survey also supports that both A/E/C firms and educational institutions should provide opportunities for designers to advance their construction experience, or obtain additional knowledge of construction processes and methods.

CHAPTER 7 RECOMMENDATIONS

Based on the results of this research the following recommendations were developed to help improve construction knowledge of designers in the A/E/C industry.

Industry Recommendations

- Establish construction-training programs for designers prior to the design stage of their design careers.

- Enhancement of construction courses taught at universities and colleges where there are architecture and engineering programs. The course work proposed could be a mixture of required and elective classes.

- The establishment of new requirements by state professional licensing boards for construction training prior to licensure.

- Industry support for a hybrid license in all states for a "Master Builder" license. Such a license would allow firms, and individuals, with demonstrated capabilities to offer design and construction services under one license.

- Insurance industry recognition of firms and individuals participating and receiving additional construction training. Such recognition could help reduce the errors and omissions rates.

- A/E/C industry-wide recognition for designers that have participated in designer construction training programs. Project owners could use this during a competitive analysis of the firms negotiating for their projects.

- Increased awareness of design firms on how inefficiencies can be corrected by construction training. Well-designed projects could help produce savings in design, construction administration, and close out man-hours. Design firms with well-established training programs and results could have a competitive advantage over firms that do not provide construction-training programs.

Future Research Recommendations

The following are areas suggested for further research.

- Research on insurance industry errors and omissions insurance standards and the establishment of rates based on construction experience factors.

- Research on a Unified "Master Builder" project delivery system requirements and investigation of benefits to the A/E/C industry.

- Nationwide surveys similar to those used in this research to identify and/or confirm trends, or results, that are similar to the data obtained for this research project.

APPENDIX I - AGREEMENT TO PARTICIPATE IN RESEARCH

The Master Builder Project Delivery System and Designer Construction Knowledge

I have been asked to participate in a research study investigating the subjects of constructability, designer construction knowledge and project delivery systems.

I will be asked to participate by completing a survey and/or being interviewed.

No foreseeable risks/benefits are anticipated by participating in this research project.

No compensation is anticipated for participating in this research project.

Any questions regarding this research project may be addressed to the principle investigator Mr. Leslie C. Battersby (408) 244-7040 x201. Any complaints related to this research project may be addressed to Mr. Akthem Al--Manaseer Phd. Chairman, Department of Civil Engineering (408) 924-3860. Questions regarding research subjects rights, or research related injury may be presented to Mr. Nabil Ibrahim, Phd Associate Vice President for Graduate Studies and Research, at (408) 924-2480

No loss of service or rights the participant currently or could be entitled to will be lost or forfeited by any participant that chooses not to participate in this research project.

We will only use this information and data in numerical summaries without identifying the origin of the information.

The subjects participating in this study do so at their own will and have given consent to participate voluntarily. All participants may freely discontinue participation in this research project at any time without prejudice to the participant's relations with San Jose State University or any other participating institutions.

The participant in this study acknowledges receipt of a signed and dated copy of this consent form.

The signature of a participant on this document indicates agreement to participate in this research.

The signature of the researcher on this document indicates agreement to include the above named participant in the research and attestation that the subject has been fully informed of his/her rights.

Participant's Signature Date

Investigator's Signature Date

APPENDIX II - SURVEY COVER LETTER

November 21, 2000

{Contacts.Prefix} {Contacts.FirstName} {Contacts.LastName}
{Company.Name}
{Contacts.DisplayAddress}

RE: Designer Construction Knowledge Research Project

Dear {Contacts.FirstName},

A research investigation is being conducted at San Jose State University in the Civil Engineering Department on Designer Construction Knowledge. This research is titled "The Master Builder Project Delivery System and Designer Construction Knowledge". This research will study the relationship of designer construction knowledge and constructability. Leslie C. Battersby will use this research to fulfill the requirements for a Master of Science degree in Civil Engineering.

You have been identified as a potential contributor to this research project, therefore, your participation in this survey is important to gathering accurate information. Attached you will find an Agreement to Participate in Research and a short survey questionnaire to be filled out additionally, a description of the research is included for your review. Please contribute your knowledge to this research project by completing the attached survey and the Agreement to Participate in Research and returning them to the above address by June 12, 2000. All information shall be kept completely confidential and a confidentiality statement is attached for your review.

Should you feel that you are not the proper person to respond to this questionnaire, forward the questionnaire to the proper person at your company. It would be appreciated if you could complete the survey and mail it or fax it to (408) 244 – 2220 no later than June 12, 2000.

If you have any questions, or concerns, regarding this survey please contact Mr. Leslie C. Battersby at (408) 244-7040 x201 or via email at les@blach.com. Please accept my sincere thanks in advance for participating in this important research.

Sincerely,

Leslie C. Battersby
Master's Candidate
San Jose State University

Dr. Janet K. Yates
Professor
Civil Engineering Department

APPENDIX III - RESEARCH INTENT

Research Intent

This research project will investigate the impact of the construction knowledge of designers on construction operations and the effects of the demise of the concept of having a "Master Builder" in charge of both design and construction of a project. This research will also investigate whether designers would benefit from some type of construction management training prior to, or at the start of, their design careers. It is theorized that many design-related problems could be reduced or eliminated by having this type of training available.

APPENDIX IV - CONFIDENTIALITY STATEMENT

April 22, 2000

It is recognized that this research may involve release of sensitive, or proprietary, information or data by members of the Architectural, Engineering and Construction industry. Recognizing the need to protect this information and data, and the potential damage the release of such information might cause, the following standards will be used for protecting all of the information and data collected:

Keeping confidential any classified data until the originator of such information allows the researcher to handle such information without concern for confidentiality.

The data and information collected will only be used in numerical summaries without identifying the origin of the information.

Prescribed administrative procedures will be followed in the identification, storage and transmittal of information and data.

The reproduction of information or data will only be done with written approval from the originator.

It is understood that the responsibility for safeguarding this confidential information and data will continue beyond the completion of the research.

Leslie C. Battersby Master's Candidate San Jose State University	Dr. Janet K. Yates Professor Civil Engineering Construction Program

APPENDIX V - SURVEY QUESTIONNAIRE

Section I – General Company and Personal Information Questions:

Please check the type of firm that best describes your company.
___ Design (Engineering) ___ Design (Architecture) ___ Design (Multiple Disciplines)
___ Construction ___ Construction Manager ___ Project Management ___ Owner or Property Manager
___Other (Please Specify_____)

How many years have you been actively employed in your field?

___ Less than 1 year ___ 1-5 Years ___ 5-10 Years ___10-15 Years ___15 or more years

Please check the category that best describes your education.

___ High School ___ Bachelors Degree (Architecture) ___ Masters Degree (Architecture)

___ Bachelors Degree (Engineering) ___ Masters Degree (Engineering)

___ Bachelors Degree (Other – Please State:_____)

___ Masters Degree (Other – Please State:_____)

___ Doctorate or Higher Education (Please list area:_____)

Please check which best describes your current position.

___Assistant Project Manager ___ Assistant Project Engineer___ Construction Manager
___ Design Enginer/Architect ___ Estimator ___ Field Engineer ___ Principal
___ Project Controls (Scheduling or Cost Control) ___ Project Engineer ___ Project Manager
___Owner or Executive ___ Staff Engineer/Architect ___ Superintendent
___ Other (Please Specify _____)

Are you a registered architect or engineer?

___ Yes ___No

___ Architect ___Engineer

What is the annual revenue of your firm?

___ $0 - $10Million ___$10-50 Million ___$50-100 Million ___$100 - 500 Million ___$500 - 1 Billion

How many people are employed at your firm?

___ 0-50 ___50-100 ___100-500 ___500-1000 ___ Over 1000

Section II – Company Training Programs:

Does your company have formal training programs for their designers?

___ Yes ___No (If no, go to question # 3)

Check the area where your company provides formal training for designers.

___ Codes/Specifications ___ Computer Technology ___ Company Policies ___ Constructability

___ Construction Methods ___ Construction Materials ___ Construction Management ___Design

___ Maintainability ___ Project Management ___ Project relationships (ie; Partnering)

___ Safety ___ Other(s) (List:_____)

Check the areas where your company provides on the job training for designers.

___ Codes/Specifications ___ Computer Technology ___ Company Policies ___ Constructability

___Construction Methods ___ Construction Materials ___ Construction Management ___Design

___ Maintainability ___ Project relationships (ie; Partnering) ___ Project Management ___ Safety

___ Other(s) (List:_____)

How many professional organizations are you a member of (ie: American Society of Civil Engineers, American Institute of Architects, National Society of Professional Engineers, etc)?

___ 0 ___ 1 ___1-3 ___ 3 or more

How many trade organizations are you a member of (ie: Associated General Contractors, American Building Contractors, etc)?

___ 0 ___ 1 ___1-3 ___ 3 or more

How many professional seminars have you attended in the last three years?

___ 0 ___ 1 ___ 1-3 ___ 3-5 ___ 5-10 ___ 10 or more

How many trade seminars have you attended in the last three years?

___ 0 ___ 1 ___ 1-3 ___ 3-5 ___ 5-10 ___ 10 or more

Does your company encourage you to visit your construction jobsites as part of your work?

___ Yes ___ No (if no go to section III, question #1)

What kinds of activities do you perform when visiting construction jobsites?
___ Attend Meetings ___Assisting Others ___ Change Order Processing ___ Contract Compliance___ Documentation (Photos and Progress Reports) ___ Estimating ___ Inspections ___ Planning and Coordination ___ Punch List ___ Observe Unique Construction Methods/Materials ___ Resolve constructability issues ___ Resolve planning and specification conflicts ___Safety Issues
___ Scheduling ___ Other (Describe:_____)

Section III – Project Delivery Systems:

Check the project delivery systems that you have participated in at work.

___ Construction Management ___ Design/Build ___ Design/Bid/Build (Traditional)

___ Fast Track Construction ___ Force Account (Owner as prime contractor) ___ Joint Venture

Please provide a rough percentage of the total revenue that you company performs for each project delivery system. (total percentage should not exceed 100%)

___ Design/Bid/Build (Competitive) ___ Design/Bid/Build (Negotiated)

___ Construction Management (involves CM firm as owners rep.) ___ Design/Build

___ Fast Track ___ Force Account

Does your company endorse, or prefer, a specific project delivery system? Please indicate by checking one selection.

___ Design/Bid/Build (Competitive) ___ Design/Bid/Build (Negotiated)

___ Construction Management ___ Design/Build ___ No preference ___ Not Sure

Are you familiar with the term "Master Builder"?

___ Yes ___ No

Select the phase that best explains your understanding of the term "Master Builder". Please indicate by checking one selection.

___ A project delivery system that includes all parties involved in a construction project from concept to operation
___ An old construction industry term that is no longer applicable to the construction industry.
___ Design firms with Architects or Engineers highly trained and educated that have extensive knowledge of both design and construction that also provides construction services.
___ Contractors that employ designers to handle all phases of a project from concept to operation
___ Construction and Design firms that perform projects via the Design/Build project delivery system.

Section IV – Construction Experience and Design: (Assume that construction field experience is defined as: Working directly on a construction project in the home office or the jobsite)

Do you think that it is important for designers to have construction field experience prior to starting their design career?

___ Yes ___No

Should designers be required to also learn about construction methods, processes and construction management as part of their formal education?

___ Yes ___No

Should designers be required to obtain construction field experience prior to receiving professional registration?

___ Yes ___No

Do you think that claims against a design firm's errors and omissions insurance would be reduced if designers had construction field experience?

___ Yes ___ No

Select the most important factor that contributes to effective construction documents?

__ Architects and Engineers that have extensive design experience
__ Architects and Engineers that have some construction experience
__ Architects and Engineers that have extensive construction experience
__ Allowing the constructor to be involved in the design phase from conceptualization
__ Allowing the constructor to be involved in the design phase after conceptualization
__ Not allowing the constructor to be involved in any of the design phases
__ Other (Please list:_____)

What level of construction field experience would you recommend for designers?

__ None required
__ Less then 1 year
__ 1- 3 years
__ 3-5 years
__ 5 or more years

Select the level of construction training your firm provides for designers? (Select One)

__ None
__ Firm holds few sessions and has no formal program
__ Firm holds regular seminars and training sessions
__ Extensive, firm has an in-house training program and encourages on-going training

Select the experience level of an on-site construction project observer/participant that you feel would best enhance design capabilities?

__ No experience
__ On – site experience limited to occasional jobsite visits as contractually required
__ Experience on 1-5 projects
__ 5 or more projects

Select the level of construction exposure you feel is important for designers to receive during their education?

__ None
__ Low (1-3 courses, electives)
__ Medium (1-3 courses, required)
__ High (3 or more courses, electives and required)
__ Very High (3 or more courses, required)

Please provide any other suggestions that you think would help enhance the educational process for design and construction engineering professionals.

APPENDIX VI - SURVEY THANK YOU LETTER

November 21, 2000

{Contacts.Prefix} {Contacts.FirstName} {Contacts.LastName}
{Company.Name}
{Addresses.DisplayAddress}

RE: Designer Construction Knowledge Research Project

Dear {Contacts.FirstName},

The researchers at San Jose State University would like to thank you for participating in the "The Master Builder Project Delivery System and Designer Construction Knowledge" research project. Your prompt return of the survey assisted in the timely completion of this important research.

The time you provided to complete the survey was greatly appreciated. The insights and answers you provided are being analyzed and the results will be included in the master thesis "The Master Builder Project Delivery System and Designer Construction Knowledge" that will be completed by August of 2000. It is hoped that this research will provide additional insight on designer construction knowledge to the Architectural, Engineering and Construction industry.

Should you have any questions, or concerns, regarding this research please contact Mr. Leslie C. Battersby at (408) 244-7040 x201 or via email at les@blach.com. Pease accept our sincere thanks for participating in this important research.

Sincerely,

Leslie C. Battersby
Master's Candidate
San Jose State University

Dr. Janet K. Yates
Professor
Civil Engineering Department
Construction Program

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