EXAMINATION OF THE CORRELATION OF CRITICAL SUCCESS AND DELAY FACTORS IN CONSTRUCTION PROJECTS IN THE KINGDOM OF SAUDI ARABIA

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The goal of all parties involved in a construction project - owners, contractors, or consultants, in either the private or public sector - is to successfully complete it on schedule, within a planned budget, with the highest quality, and in the safest manner. Construction projects are frequently influenced by either success factors that help project parties reach their goal as planned, or delay factors, that stifle or postpone project completion. Accurately identifying success and delay factors can help project parties reach their intended goals with greater efficiency. This study extracted seven of the most important success and delay factors according to the literature (14 total success and delay factors), and then examined correlations between them to determine which were the most influential in preventing project delays. Two surveys were distributed throughout the Kingdom of Saudi Arabia. The first examined how project owners and contractors that collaborated on the same project perceived success and delay factors, while the second examined the perceptions of engineers in general. Data was collected and evaluated by statistical methods to measure the strength and direction of the relationship between critical success and delay factors, to examine owners' and contractors' evaluations of projects' critical success and delay factors, and to evaluate the influence of critical success factors on critical delay factors. Additionally, one and two-way analysis of variance (ANOVA) has been used to

examine how the group or groups evaluated the influence of the critical success factors in avoiding or preventing each of the delay factors, and which success factors were perceived as most influential in avoiding or preventing critical delay factors.

The research found that sound organization planning efforts and a competent and experienced project manager helped to avoid many critical delay factors, while adherence to safety precautions and procedures and a project team's motivation and goal orientation were the least influential among the seven success factors.

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PREFACE

These acknowledgments attempt to thank the people who in some way supported, guided, and encouraged me along the way to completing this dissertation; it is difficult to include every one because there are so many individuals who helped me both directly and indirectly throughout the course of my studies.

First, all praise and thanks are due to Allah, the Merciful, the Compassionate, who provided me with health, strength, and success. He helped and guided me to overcome difficulties and obstacles during the entire duration of my study

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1.0 OVERVIEW OF THE CONSTRUCTION INDUSTRY

The construction industry is incredibly important in all economies. In many cases, it is what drives the overall economy. In the United States, as well as other nations, construction is one of the largest economic sectors. Until the 1980s, construction was responsible for the largest percentage of the gross domestic product (GDP), and the highest dollar turnover of any U.S. industry. Even today, construction is the largest manufacturing industry in the United States, accounting for approximately 8% of the GDP (Halpin & Woodhead, 1998).

Due to the importance of the construction industry in a nation's economy, it is worthwhile to ensure construction projects are completed successfully. There are a number of ways to achieve this; one way, which this research investigates, is by providing managers with valuable skills that can aid successful completion of a project. This means providing managers with tested methods of managing resources such as workers, subcontractors, equipment, the construction plant, materials, money, and time.

As Nunnally (2001) noted, poor construction management practices usually result in one or more of the following issues:

- Project delays, which increase labor, equipment costs, overhead cost, insurances, and often require the borrowing of additional funds.
- High cost of materials, caused by inefficient handling of purchasing decisions.
- Increased subcontractor cost, and poor contractor/subcontractor relations.
- High insurance costs due to material and equipment damage, or a poor safety record.

- Low profit margin or loss on construction volume.

These issues will present themselves on a smaller scale to members of the project circle, such as contractors, owners, consultants, and subcontractors. However, on a larger scale these issues will affect larger components of society, namely the economy.

1.1 CONSTRUCTION CLASSIFICATION

Strategies and operational relationships between construction project parties are directly related to the type of construction project, and there are different ways to classify them. According to Halpin and Woodhead (1998) there are three major construction categories:

- Heavy and Highway: Construction of highways, bridges, airports, pipelines, dams, and tunnels.
- Nonresidential buildings: Either institutional or educational buildings (such as schools or universities, warehouses, and government buildings) or industrial (such as petroleum refineries or nuclear power plants).
- Residential: Construction of single-family homes, multiunit town houses, or high-rise buildings.

Figure 1.1 shows how industry is distributed in the United States by dollar value, according to the classifications listed above (Halpin and Woodhead, 1998 p.15):

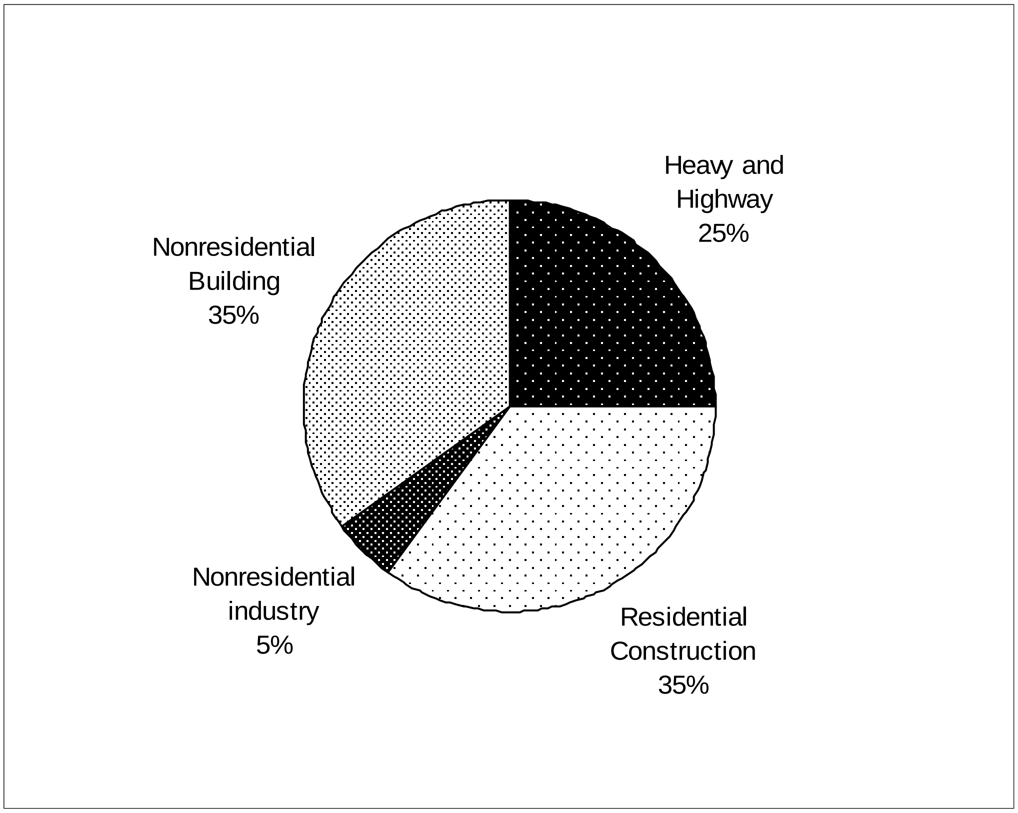

Figure 1-1 Construction Industry in the United States

1.2 PROJECT PARTIES

The primary construction project parties are:

a) Owner: Owners play the most important role in the construction project life cycle by defining project requirements, functions, and services. Also, owners are responsible for providing financial support to a project.

b) Contractor: Firms or individually generally contract with owners in order to execute certain projects according to specific conditions.

c) Designer (Architect/Engineer; A/E): The third party in construction projects is designers, who interpret the owner's needs and create a tangible blueprint of a project. For some projects, the designer also assumes the role of supervising activities during the construction phase. Figure 1.2 shows the relationship between involved project parties.

CONTRACT PARTY	ROLES
Owner	➢ Determines whether it is necessary to build the facility ➢ Provides financial support to develop the project ➢ Determines the scope of work ➢ Most important player in the process
Contractor	➢ Creates the facility based on the A/E's drawings and specifications ➢ Manages different resources during the project's development phase
Architect / Engineer (A/E)	➢ Responsible for project design ➢ Fortifies the final project ➢ Determines which materials will be used and how they will fit together ➢ Develops the project's drawings and specifications

Figure 1-2 Construction Project Parties Roles

1.3 PROJECT DEVELOPMENT

Traditionally construction projects develop in a clearly sequential fashion, and the general steps involved are as follows:

a) Need for a facility is defined by owner.

b) Initial feasibility and cost projections are developed.

c) The decision to either proceed with the conceptual design or improve the idea is made.

d) The conceptual design and scope of work is developed in order to determine a cost estimate.
e) A decision is made to proceed with the development of final design documents.
f) Based on the final design document, the project is advertised and proposals, including costs for construction work, are solicited.
g) Based on the received proposal, a contractor is selected and instructed to proceed with work.
h) The process of constructing the facility is initiated.
i) Work is completed and the facility is available for acceptance and occupancy/utilization.
j) A period of testing takes place to ensure the facility is constructed properly and operates as designed.
k) The facility operates and is maintained for the duration of its specified service life.

We have seen the importance of the construction industry in the economy in general and a simple overview of the project development process. In all stages of the project proper care must be taken by the parties to ensure that the project progresses smoothly. Any deficiencies or misapplication of agreed upon decisions may cause delays, or in the worst case scenario, bring the project to a complete halt. Improving the chances to complete the construction project as scheduled is vital for all the project participants as well as for the overall economy.

2.0 CONSTRUCTION PROJECT SUCCESS AND DELAY FACTORS

(Ashley et al 1987) defined project success as "results better than expected or normally observed in terms of cost, schedule, quality, safety, and participant satisfaction" (p. 69). In the construction industry, as well as other business industries, construction project parties involved in a project aim to complete it successfully. During the last four decades a number of studies have investigated factors which aid successful completion of a project. More attention has been given to special area or factors that might affect project success more than others. "Critical success factors thus are, for any business, the limited number of areas in which results, if they are satisfactory, will ensure competitive performance ..." Rockar 1982 (p. 3).

On the other hand, all too often construction projects are completed with large cost overruns, extended schedules and quality issues. The delay in a construction project may cause losses or negatively affect some or all of the project parties. Some studies directly examined delays and attempted to identify their causes, as well as ways to avoid them. Baldwin (1971) was the first to examine construction project delay factors, and his findings were taken further by other researchers who were also interested in delay factors. However some researchers were not interested in which factors caused delays, but which were responsible for successes. The first study to identify critical success factors was David Ashley (1987), who identified which factors were most influential in successfully completing construction projects.

The present work also follows these past studies by relying upon the success and delay factors they identified. However, it goes in a new direction. Namely, the hypothesis is that the presence of one or more success factors may be influential in reducing one or more delay factor effects. Consequently, this work examines success and delay factors in an integrated fashion to determine which critical success factors were most influential in avoiding critical delay factors. This would give organizations involved in construction projects a better idea of how to potentially avoid delays. Lastly, the study focused on construction projects in Saudi Arabia, which was used as a case study to examine the correlation and effectuality of critical success and delay factors.

2.1 SAUDI ARABIAN CONSTRUCTION PROJECTS AS A CASE STUDY

Throughout the years the Saudi Arabian construction industry has gone through a number of different stages. The first major stage began in 1970, with the introduction of 5-year plans; it was at this time that construction became an industry of importance in Saudi Arabia alongside more traditional industries, such as petroleum production. Through government grants and interest-free loans, citizens were encouraged to build and invest in numerous projects of different types, sizes, and functions. Additionally, there was an urgent need to develop the country's infrastructure. These initial years of growth were accompanied with a great deal of economic prosperity, and many seized this opportunity by establishing their own construction firms, leading to the rise of many well-known and recognizable firms that had a great impact on the construction industry. Unfortunately, many of these endeavors were handled inadequately, especially in light of such high public demand for the creation of residential and commercial buildings.

With the beginning of the fourth 5-year plan in 1985, financial support for the development of institutions and buildings dwindled, and the number of new companies decreased as well. This decrease was due to a number of different factors, such as:

- Increased competition;
- Scarcity of profit and high investment risk;
- The discovery of many defects in previously constructed buildings, which led to tarnished reputations, as well as legal battles for contractors; many were no longer able to work in the construction field.

A brief look at the history of contracting in Saudi Arabia indicates that many problems could have been reduced or eliminated by the implementation of a clear mechanism for managing construction projects. Proper management is key to encouraging engaged partners to carry out corrective actions whenever necessary, and prevents deterioration during implementation that might lead to the cancellation of projects, paying of penalties for delays, as well as a number of other potential problems.

2.2 STAGES OF THE SAUDI ARABIAN CONSTRUCTION INDUSRY

The Saudi construction industry has gone from an initial boom to recent decline. However this decline is not negative in nature, and merely marks the equilibrium between a virtually non-existent construction industry and an overly abundant, frequently insufficient one. The 5-year plans discussed earlier have played a pivotal role in reaching this natural balance, and are outlined below

2.2.1 Stage One

This stage includes years prior to 1970, before an official national plan was established. Most infrastructure projects were executed or designed during this period, including many famous palaces and dams that became a part of traditional architecture in Saudi Arabia. However, construction materials available at this time were limited to local raw materials.

2.2.2 Stage Two

The second stage began with the first 5-year development plan in 1970, and ended in 1980. This development plan was established to prompt systematic construction of a modern Saudi infrastructure, and laid the foundation for the country's long-term strategic goals. During the 1970s Saudi Arabia experienced an extremely high level of activity, which attracted construction professionals from all over the world. It was at this stage that most of the infrastructure and major projects such as military cities, airports, highways, and hospitals were built.

2.2.3 Stage Three

This stage has been referred to as the declining stage (1980 - 1990), where family firms and small companies found it difficult to compete with other larger, more qualified companies in a narrowing construction market. In the latter part of this period many construction companies closed their doors, and found it difficult to survive; companies that did not go out of business were merged with others.

2.2.4 Stage Four

This period can be called the corrective stage; it began in the early 1990s and included companies that survived the ups and downs of the previous years. In this stage, government organizations relied upon previous experience and used this knowledge to develop industry regulations such as contractor prequalification, safety requirements, site supervision, and consultant office regulations. Contractors in this time found themselves forced to reorganize their previous work methods and more extensively plan future projects, recruit qualified workers, and use new technology prevalent in the industry. All of these corrective measures helped to improve the overall strength and competitiveness of Saudi Arabia's private sector companies.

2.3 IMPORTANCE OF THE STUDY

The researcher's own experience with construction projects in Saudi Arabia is generally in agreement with problems commonly identified in the literature. Common contractors problems include project delay, where the project is not completed within the specified period; lessened quality levels; exceeded budgets; use of unspecified materials; unqualified employees; selling the projects after they are awarded; unrealistic joint ventures; project withdrawals and failures; future maintenance problems due to improper construction methods; and safety problems such as project site accidents.

Whether they realized it or not, owners exhibited similar deficiencies as well, either directly or indirectly due to limited experience, or insufficient investigation. Owners had additional problems beginning with the design phase; for example, some projects designed outside of the kingdom could be mismanaged if the designer failed to visit the project's actual site, and examine its conditions. Additionally, some of the owners or owners' representatives were less-than-generous with contractors, limiting the amount of profit they could make on their projects; other owners or service organizations began to exercise bureaucratic authority over the contractors, and made unrealistic special requests and orders after the contract had been signed. Some of these demands included requesting specific subcontractors or materials, or cutting the costs of any additional work. Furthermore, the owners sometimes did not perform necessary prequalification procedures and failed to rely upon valid contractor information. Instead, they blindly trusted documents submitted by contractors and made no effort to verify that the projects mentioned in them (previously executed projects) were genuinely and carefully executed by the contractor.

These problems all have a negative effect on the parties involved, generate a great deal of loss for everyone, threaten the general safety of construction projects, and eventually affect the economy as a whole. In light of these points, this project investigates such problems and pinpoints the delay factors and the necessary success factors that could help to prevent or eliminate them in construction in general, with a specific focus on Saudi Arabia, where the case study was conducted and where the researcher has extensive experience.

2.4 OBJECTIVES

The main objective of this study is to examine the correlation between critical success and delay factors in construction projects, and to identify which critical success factors are most influential in avoiding or preventing critical delay factors based on the critical success and delay factors which have been identified in the literature. These objectives have been tested and examined using Saudi Arabian construction projects as a case study.

2.5 SCIENTIFIC ASPECTS OF THE STUDY

No previous studies that discussed the relationship between success and delay factors in construction projects were found in the literature, and this appears to be the first to do so. This study is also the first to measure and rank these relationships so that it will help project parties minimize construction project problems

2.6 PROBLEM STATEMENT

Simply applying critical success factors or taking the necessary precautions to avoid critical delay factors during construction might not be enough to help project parties meet a contract's original specifications. Studying the correlation between both the critical success and the critical delay factors, and examining the effect of the identified critical success factors on each of the critical delay factors directly would shed some light on which factors are most influential upon one another, and aid contract parties and investors in deciding which factors deserve the most attention.

2.7 RESEARCH MOTIVATION

From first-hand experience the researcher noticed that for every finished project a number of deficiencies or delay factors occurred, and continued to occur in subsequent projects either in the exact same fashion or in a slightly different form. Occasionally, completely new problems would develop. Despite efforts to implement success factors, problems persisted. While a body of research exists identifying major causes of project delay as well as success, no research exists illustrating how critical success and delay factors interact together, and how knowledge of this interaction may lead to more successful projects. It is this gap in the research literature that motivated the current study.

2.8 RESEARCH QUESTIONS

The following set of questions will be used to guide the integrated study of critical success and delay factors.

1. How do specific critical success factors affect individual critical delay factors?
2. Do these relations vary by project affiliation (owner, contractor)?
3. Does the influence of critical success factors on each critical delay factor vary by specific project respondents' or general experience engineers' opinion?

3.0 LITERATURE REVIEW

This chapter defines and describes project delay factors and success factors identified in the literature, and examine other research about this topic.

3.1 DELAY FACTORS

Delay can be defined as extra time required to finish a given construction project beyond its original (planned) duration, whether compensated for or not. The desire to finish a project on time, under the planned budget, with the highest quality, and in a safe manner are common goals for all contract parties, including the owner, contractor, and consultant – delays cause losses for everyone. To control this problem and minimize construction project delays, engineers should identify the causes of delays and the project factors that may avoid them. The following literature review and summarizes some of the studies and research conducted on construction delay.

3.1.1 Causes of Delay in the Construction Industry

(Baldwin et al. 1971) was the earliest reference found in the literature that examined the subject of delays. Baldwin et al. noticed that large construction projects experienced considerable injury and loss when they encountered any kind of delay. The study included a total of 1400 questionnaires: 400 were mailed to contractors, 500 were mailed to architects, and 500 were mailed to engineers. A questionnaire was sent to selected members of all three groups in every state. Survey was slightly modified before sending the questionnaire to the architects and engineers in order to clarify the intent of some questions. 61% of the surveys were returned by contractors, 44% by architects, and 30% by engineers. In spite of the different viewpoints held by each of the groups surveyed, there were definite areas of agreement among them. All three groups felt that weather, labor supply, and subcontractors' scheduling were the three major causes of delay. The complete list is found in Figure 3.1.

3.1.2 Causes of Delay in Large Building Construction Projects

The (Assaf et al. 1995) study was undertaken in two phases. The first phase included a literature review and interviews with local contractors, architectural engineers, and owners, where fifty-six causes of delay were identified. These factors were grouped into nine major categories: materials, manpower, equipment, financing, environment, changes, government relations, contractual relationships, and scheduling and controlling techniques. In the second phase, a questionnaire was developed that focused on the fifty-six causes of delay. A survey was conducted to assess the relative importance of the cause of delay on large building projects valued at 10 million Saudi Riyals or more ($1 = 3.75 SR). The questionnaire was filled out by 24 contractors, 15 architects and engineers, and nine owners.

The collected data were analyzed using an importance index as shown below

$$I = \sum_{i=1}^{i=4} \left(\left(a_i x_i \right) / 3 \right)$$

Where I = importance index; a_i = constant expressing the weight of the ith response, where a_i = 0,1,2,3, for i = 1,2,3,4 respectively; x_i = frequency of the ith response given as a percentage of the total responses for each cause of delay.

Contractors	Architects	Engineers
Weather	Subcontractors	Weather
Labor supply	Labor	Subcontractors
Subcontractors	Weather	Labor
Design changes	Manufactured items	Manufactured items
Shop drawings	Finances	Finances
Foundation conditions	Material shortage	Foundation conditions
Material shortage	Shop drawings	Permit
Manufactured items	Permit	Material shortage
Sample approvals	Foundation conditions	Design changes
Jurisdictional disputes	Design changes	Shop drawings
Equipment failure	Construction mistakes	Jurisdictional disputes
Contracts	Jurisdictional disputes	Equipment failure
Construction mistakes	Sample approvals	Construction mistakes
Inspection	Building Codes	Inspection
Finances	Contracts	Contracts
Permit's	Equipment failure	Sample approvals

Figure 3-1 Delay Factors in Order of the Importance

An agreement between the rankings of any two parties was measured using the rank correlation coefficient. The study found that all three groups generally agreed on the ranking of the delay factors (financing was ranked the highest by all three parties, and the environment was ranked the lowest). The most important factors found by this study and their ranking as ranked by contractors, architectural engineers, and owners are shown in Tables 3.2, 3.3, and 3.4 respectively.

Table 3-1 the Most Important Delay Factors According to Contractors

Type	Delay factor	Rank
Scheduling	Preparation and approval of shop drawings	1
Financing	Delays in contractors progress payment by owner	2
Changes	Design change by owner during construction	2
Material	Delay in the special manufacture out side of Saudi Arabia	4
Financing	Owners cash problems during construction	5
Contractual relationship	Slowness of owner's decision making process	6
Material	Slow delivery of construction material	7
Changes	Design errors made by designers	7
Scheduling	Waiting for sample materials to be approved	7

Table 3-2 the Most Important Delay Factors According to Architectural Engineers

Type	Delay factor	Rank
Financing	Owners cash problem during construction	1
Financing	Financing by contractors during construction	2
Contractual relationships	Relationship between different subcontractors schedules	2
Contractual relationships	Slowness of owner's decision making process	2
Financing	Delays in contractors progress payments by owner	5
Materials	Changes in type of construction materials	6
Scheduling	Poor judgment of involved people in estimating time	6
Contractual relationships	Controlling subcontractors by general contractors	6

Table 3-3 the Most Important Delay Factors According to Owners

Type	Delay factor	Rank
Changes	Design errors made by designers	1
Government relationships	Excessive bureaucracy in project owner operation	2
Manpower	Shortage of manpower	3
Manpower	Labor skill	3
Financing	Financing by contractor during construction	3
Material	Shortage of construction material	6
Financing	Owner's cash problems during construction	6
Changes	Errors committed during field construction on site	6
Contractual relationships.	Unavailability of professional construction management	6

3.1.3 Construction Delay: A Quantitative Analysis

One of the objectives of (Al-Momani, 2000) was to determine the cause and extent of delays in public projects in Jordan. The study investigated the cause of delays for 130 projects, including residential buildings, office and administration buildings, schools, medical centers, and communication facilities. The sample population was established by selecting 130 finished public projects in different regions of Jordan between the years of 1990 and 1997. To investigate why construction delays and overruns occurred, the following data were obtained from the projects' records:

- Planned duration of contract
- Actual completion data
- Design changes
- Disputes
- Notifications
- Date of notice to proceed
- Delays encountered during construction
- Conflicts related to the drawings and specifications
- Time extensions
- Late delivery of material and equipment

As shown in Table 3.4, the frequencies for each parameter in five different construction categories were provided, and many projects were delayed for various reasons. The study found that the major causes of delay were poor design, change orders, weather, site conditions, late delivery, economic conditions, and increase in quantities. The main causes of delay found in this study were poor design, change order and site and economic conditions.

Table 3-4 Summary of the Investigated Projects Frequency of Delay

Facility Type	Poor Design	No Delay	Change Orders	Weather	Increase in Quantity	Late Delivery	Site Condition	Economic Conditions	Total
House	4	3	1	3	2	0	1	0	14
Office	8	5	5	4	5	1	2	4	34
School	10	14	8	6	3	4	5	2	52
Hospital	6	2	4	2	1	3	0	2	20
Roads	4	0	2	1	1	2	0	0	10
Total	32	24	20	19	12	10	8	8	130

3.1.4 Construction Delay in a Fast Growing Economy

(Ogunlan et al. 1996) conducted a survey examining the delays experienced while constructing high-rise buildings in Bangkok. Twelve projects were selected for visitation and interviews were conducted with their head engineers. Interviews were conducted at the project sites, and a total 30 individuals were interviewed, representing 2.5 persons per project. Interviewees were allowed to freely discuss the reasons for their project's delays and identify the parties involved. The details of the causes of delay can be found in Table 3.5.

3.1.5 A Comparative Study of Causes of Time Overruns

(Chan and Kumaraswamy, 1997) presented the results of a survey undertaken to determine and evaluate the relative importance of the significant factors causing delays in Hong Kong construction projects. The survey covered 83 previously identified project delay factors, which were grouped into eight major factor categories: project related, client related, design team related, contractor related, materials, labor, plant/equipment, and external factors.

The researchers used the relative importance index technique – RII (Equation 1) together with rank agreement factors and percentage agreement to analyze survey data, concluding that:

$$\text{RII} = \frac{\sum w}{A \times N}\ ,\ (0 \leq \text{index} \leq 1)$$

Where

w = weighting given to each factor by the respondents and range from '1' is not significant and '5' extremely significant.

A = highest weight

N = total number of respondents

a) All three major groups of industry participants felt that poor site management and supervision, unforeseen ground conditions, slow speed of decision making involving project teams, client-initiated variations, and necessary variations of work were the five most significant sources of construction time overrun.

b) Despite some differing perceptions as to the relative importance of delay factors suggested by each group of respondents, there was general agreement between the client and consultants on a set of 10 principal factors, but the contractors only agreed with some of them.

c) The clients and consultants claimed that for the most part, the delays were attributable to a lack of contractor experience in planning and monitoring at the site. Respondents' rankings of significant delay-causing factors are shown in Table 3.6.

Table 3-5 Sources and Causes of Construction Delays

#	Source	Reason for delays	No. of Projects	Affected % of all projects (n = 12)
1	Owners	➢ Change order ➢ Slow decision making	5 4	41.7 33.3
2	Designers	➢ Incomplete drawings ➢ Slow response	9 8	75 66.7
3	CM or inspector	➢ Deficiencies in organization ➢ Deficiencies in coordination ➢ Uncompromising attitude ➢ Delays in work approval	4 3 3 2	33.3 25 25 16.7
4	Contractors	➢ Materials management problems ➢ Deficiencies in organization ➢ Coordination deficiencies ➢ Planning and scheduling problems ➢ Equipment allocation problems ➢ Financial difficulties ➢ Inadequacy of site inspection	9 9 8 7 5 4 4	75 75 66 58 41.7 33.3 33.3
5	Resources and suppliers	➢ Shortage of construction materials ➢ Shortage of site workers ➢ Insufficient numbers of equipment ➢ Late delivery ➢ Shortage of technical personnel	11 9 7 6 6	91.7 75 58.3 41.7 41.7
		➢ Frequent equipment breakdowns ➢ Price escalation ➢ Low quality of materials	3 2 1	25 16.7 8.3
6	Others	➢ Confined site ➢ Problems with neighbors ➢ Slow permits from government	6 3 2	41.7 25 16.7

Table 3-6 Respondents' Rankings of Significant Delay Factors

#	Cause of delay	Consultants	Contractors	Clients
1	Poor site management and supervision	1	3	1
2	Unforeseen ground conditions	2	19	5
3	Client-initiated variations	3		
4	Low speed of decision making involving project team	4		
5	Necessary variations of work	5	13	6
6	Lack of communication between consultant and contractor	6	9	9
7	Improper control over site resource allocation	7		3
8	Delays in subcontractors' work	8	11	18
9	Inadequate managerial skills	9		2
10	Inadequate contractor experience	10	12	4
11	Inappropriate overall organizational structure	11	7	
12	Project construction complexity	12		11
13	Unsuitable management structure and style of contractor	13		
14	Low speed of decision making within each project team	14	15	20
15	Lack of communication between client and contractor	15		15
16	Slow information flow between project team members	16	20	

Table 3-6 Continued

17	Unsuitable leadership style of contractor's manager	17		
18	Lack of communication between client and consultant	18	16	
19	Poor procurement programming of materials	19		16
20	Delay in design information	20	1	
21	Long wait for approval of drawings		2	
22	Unrealistic contract duration imposed by client		4	13
23	Mistakes and discrepancies in design documents		5	
24	Long wait for approval of test samples of materials		6	
25	Inadequate design team experience		8	
26	Low speed of decision making involving all project teams		10	12
27	Disputes and conflicts		14	
28	Shortage of material in market		17	17
29	Client-initiated variations		18	10
30	Poor site management and supervision			7
31	Shortage of skilled labor			8
32	Contractors' deficiencies in planning at preconstruction stage			14
33	Low labor productivity			19

3.2 SUCCESS FACTORS

Success is defined by (Ashley et, al.1987) "as results much better than expected or normally observed in terms of cost, schedule, quality, safety and participant satisfaction". The investigation of the success factors of construction projects has attracted the interest of many researchers and many studies have been conducted in this field. The predominant aim of these research efforts has been to provide contract parties with valuable insight into how they can consistently achieve the superior results they are seeking. Although construction projects are by their nature comprised of repetitive activities, each one has its own characteristics and circumstances. The following section discusses some related studies that identify the most critical success factors leading to successful completion of a project on time, within a planned budget, in the safest manner, and with the highest quality. These studies differ in the way they approach the problem and in the way the researchers evaluate success factors.

3.2.1 Determinants of Construction Project Success

(Ashley et al.1987) offered insight into potential factors that influence construction project effectiveness through interviews with construction project personnel and a literature review of relevant studies. Researchers started with a list of approximately 2000 success factors from previous studies and construction management personnel interviews, which they reduced to 46 success factors which are and then grouped into 5 major areas:

a) Management, organization, and communication

b) Scope and planning

c) Controls

d) Environmental, economic, political, and social

e) Technical

In order to identify which of these factors appeared to have the most significant influence on construction project success, input from several construction project personnel was obtained. Each factor was subjectively rated using a range from no influence measured as a value of one (1), to major influence measured with a value of five (5). From these ratings the top 15 factors were grouped by their respective categories. From this list, 11 factors were chosen for further analysis:

1. Planning effort
2. Project manger goal commitment
3. Project team motivation and goal orientation
4. Scope and work definition
5. Project manger capability and experience
6. Safety
7. Control systems
8. Design interface management
9. Risk identification and management
10. Technical uncertainty
11. Legal political environment

The next step was to determine if these 11 factors could be statistically correlated to project success. A survey instrument was designed to find these correlations. Eight companies participated, with each company contributing one average project and one outstanding project for analysis; thus, a total of 16 projects were used. The individuals surveyed were experienced in project management covering a wide range of project types. Individuals were selected who had extensive experience with the project. The main objectives of these interviews were to identify factors that appeared to show a difference between average and outstanding projects, identify principal measures of project success, and identify factors that showed a strong correlation to successful project outcomes.

Response data from these interviews were analyzed using different techniques. One of these, percentage differences, was computed between average and outstanding responses for each factor. A second technique compared two sample t test to show whether these percentage differences were statistically significant. Finally, a correlation analysis was performed to see if any of the factors had a relationship to construction project success.

Differences were found to exist between mean responses for average and outstanding projects on the factors that were identified. There was a clear distinction in factor differences between average projects (M = 3.44) and outstanding projects (M = 4.09). A rating scale was used where 1 = poor, 2 = below average, 3 = average, 4 = above average, and 5 = outstanding. Construction and design planning efforts showed the greatest amount of separation between the two types of projects. This could mean that the amount of planning has the greatest impact on the overall success of a project. From this analysis, the researchers found that the first seven factors were the most significant factors in determining project success. The other factors showed less separation between average and outstanding projects, and therefore were probably not as important in determining the success of a project.

Likewise, success criteria were comparatively rated for average and outstanding projects. Differences were examined by determining the percentage difference between the mean of the average and outstanding projects, revealing that the most important criteria to measure success of a construction project were:

1. Budget
2. Schedule
3. Client satisfaction
4. Functionality
5. Project manager / team satisfaction
6. Contractor satisfaction

The last analysis technique was correlation, which was performed to determine whether or not a particular factor influenced the success of the construction project. A total of 140 regressions were performed using each success factor as an independent variable, and each success criteria as a dependent variable.

In conclusion, the results showed that statistically significant differences existed between average projects and outstanding projects in key areas such as:

1. Construction and design planning effort
2. Project manager goal commitment
3. Project team motivation
4. Project manger technical capabilities
5. Scope and work definition
6. Control systems
7. Safety

8. Design interference management
9. Risk identification
10. Technical uncertainty
11. Legal political environment

(Adapted from Ashley et al 1987 page 74)

3.2.2 Critical Success Factors for Construction Projects

(Sanvido et al 1992) defined the success of construction projects as the degree to which project goals and expectations are met. These goals and expectations may include technical, financial, educational, social, and professional aspects. The (Sanvido et al 1992) study covered all the project phases, including design, construction, and maintenance. The researchers identified the success criteria list for each of the contract parties: owner, designer, and contractor. Some of the owner success criteria included being on schedule, being on budget, and return on investment. Examples of the designer success criteria were client satisfaction, quality architectural product, well-defined scope, and social acceptability. Finally, contractors' criteria for measuring success included meeting the schedule, profit, being under budget (savings obtained for owner and/or contractor), safety, and client satisfaction.

Many criteria items or viewpoints were similar for all three parties; for example, the financial reality of doing business and meeting an appropriate schedule were seen as ways of measuring the success of a project by all. On the other hand, there were some unique criteria. For example, the designer was looking for a project that would increase the level of professional satisfaction among his employees. Safety was a high priority for the contractor, and the owner was extremely interested in knowing that the building projects functioned properly for their intended use and were free from long-term defects or lingering maintenance problems.

This study was concerned with some issues such as valid construction project success factors for building projects and whether these were the same or different in importance for different types of buildings, such as hospitals versus office buildings.

A questionnaire was developed to facilitate data collection by the researchers and to ensure consistency in the elements examined. The study selected eight pairs of projects; the two projects in each pair were similar in scope and proposed by the same sponsor or company. One project was successful in the eyes of the sponsor and the second was less successful. The researchers made site visits to the selected projects and interviewed the principal engineers. The interviewee was asked to rank how successful the project was, they also asked to determine whether the function (like facility team, experience, external constrains, resource, etc…) had either positive or negative effect on the project's success and what that effect was, and what lessons learned from the project and what had been done to implement those lessons in subsequent projects

The results of the research indicated that the following four factors were critical:

a) A well-organized, cohesive facility team to manage, plan, construct, and operate the facility.
b) A series of contracts that allowed and encouraged the various specialists to behave as a team without conflict of interest and differing goals.
c) Experience in the management, planning, design, construction, and operations of similar facilities.
d) Timely, valuable optimization information from the owner, user, designer, contractor, and operator in the planning and design phase of the facility.

3.2.3 Checklist of Critical Success Factors for Building Projects

(Sanvido, et al 1992) has determined the existence of a set of critical project success factors that play an important role in the planning, design, and construction of successful building projects. (Parfitt and Sanvido, 1993) used those success factors to develop a checklist that could be used by building professionals to predict the success of a project. A brief example of this checklist is given below:

Facility team:

- Have adequate steps been taken to assemble and build a facility team with the common goals and chemistry appropriate for this project?

-- Is a sense of respect for the role and services of each team member evident?

-- Is there an open and honest communication flow?

-- Do all team members share a compatible philosophy with the owner of this project

3.2.4 Critical Success Factors for Different Project Objectives

(Chua et al, 1999) identified critical success factors for construction projects based on the accumulated knowledge and judgment of experts in the industry. Sixty-seven success related factors were considered and grouped under four main project aspects: project characteristics, contractual arrangements, project participants, and interactive process. A questionnaire was developed to facilitate systematic data collection. Some of the questionnaire items were designed to collect background information about the respondent, and others invited the respondents to consider the relative importance of a pair of success-related factors at each time, based on a nine-point scale. Twenty experienced practitioners with an average of 20 years experience in the construction project industry participated in the study. The analytical hierarchy process (AHP) was used to collect consistent and subjective expert experiences about success factors for construction projects. The collected data were analyzed using Expert Choice 1996, a software package that incorporates AHP. The top 10 success factors based on the averages of budget performance, schedule performance, quality performance, and overall responses are displayed in Table 3.7.

The results of the study revealed that experts agree that there are different sets of construction success factors for different project objectives. They determined that the probability of project success can be increased if the inherent characteristics of the project are thoroughly understood, appropriate contractual arrangements are adopted, a competent management team is assigned, and a sound monitoring and control system is established.

Table 3-7 Critical Success Factors for Different Project Objectives

Success factors	Budget	Schedule	Quality	Overall
Adequacy of plan and specifications	1	1	1	1
Constructability	2	2	2	2
Project manager commitment and involvement	8	3	4	3
Realistic obligations and clear objectives	3	6	5	4
Project manger competency	5	4	6	4
Contractual motivation and incentive	9	5	10	6
Site inspection	-	10	3	7
Construction control meetings	-	8	7	8
Formal communication during construction	-	-	8	9
Economic risks	3	-	-	9

3.3 CONCLUSION

The common objective of the previous studies that investigated success and delay factors individually was to help the project parties successfully complete a project. The goal of this research is to extend these efforts by examining correlations between the most effective success factors and the most common delay factors as identified in the literature, and to determine how the most critical success factors could help to avoid or prevent the most critical delay factors.

3.3.1 Delay Factors

Previous research mainly investigated this topic from two points view: the first one is from project participants such as owners, contractors, and architectural engineers. Similar to studies on critical success factors by (Baldwin et al. 1972), (Assaf et al.1995), (Ogunlan et al.1996) and Chan and (Kumaraswamy1997), the most critical effective delay factors were identified from the construction project participants and those studies classified these delay factors using different importance and ranking methods. The other type of study is typified by Al-Momani, (2000), which studied this topic by reviewing project files for 130 different projects and determining the critical delay factors based on their frequency in the sample projects. The two points of view generally agreed on the most important delay factors affecting construction projects. (Assaf et al.1995) was the most comprehensive study. It had extended prior studies and supported conclusions about critical delay factors from more recent studies. The critical delay factors were categorized into nine groups and were ranked based on these groups. The current research is mainly concerned with the study of individual critical factors. As such, the 56 causes of delay identified by (Assaf et al.1995) have been ranked first by average (owners, contractors, and engineers) and by a cumulative index. Table 3.8 showed the first 14 causes of delay from. (Assaf et al.1995). The average rank is calculated as follows: Delay factor one, Cash problems during construction:

Ranked as 6^{th} by the owners,

5^{th} by the contractors,

1^{st} by the A/E

Average rank for this delay factor:

$(6+5+1)/3 = 4^{th}$

On the other hand, the importance index for this delay factor was:

71 owners, 70 contractors, and 86 engineers

Cumulative importance index:

71+70+86= 227

The first seven delay factors in Table 3.9 have been chosen for further investigation in this research.

3.3.2 Success Factors

In this study, the previous studies regarding success factors were reviewed, with special attention given to (Ashley et al.1987) due to its comprehensive, detailed descriptions, and because much of the other research was based upon it in some way. The seven most significant success factors in determining project success in (Ashley et al.1987) have been chosen for further investigation in this study, which were:

Table 3-8 Causes of Delay Based on the Average Rank and Cumulative Index

#	Delay factors	Owner		Contractor		A/E		Ave. Rank	Index
		Index	Rank	Index	Rank	Index	Rank		
1	Owners cash problems during construction	71	6	70	5	86	1	4	227
2	Delays in contractor's progress payment by owner	67	10	78	2	74	5	5.7	219
3	Slowness of owner's decision making process	67	10	70	5	79	2	5.67	216
4	Financing by contractor during construction	76	3	55	18	79	2	7.7	210
5	Design errors made by designer	81	1	68	9	57	15	8.33	206
6	Excessive bureaucracy in project owner operation	81	2	59	13	64	11	8.67	204
7	Changes in type of construction material	67	10	67	10	69	6	8.67	203
8	Shortage of construction material	71	6	67	10	64	11	9	202
9	Design change by owner during construction	57	17	78	2	67	9	9.33	202
10	Preparation and approval of shop drawings	57	17	79	1	64	11	9.67	200
11	Slow delivery of material	62	14	68	7	62	16	12.3	192
12	Relationship between subcontractors' schedules	57	17	56	18	79	2	12.3	192
13	Uncooperative owner	57	17	63	12	68	9	12.7	188
14	Delay in the special manufacture	43	42	76	4	62	16	20.7	181

1. Construction and design planning effort
2. Project manager goal commitment
3. Project team motivation
4. Project manger technical capabilities
5. Scope and work definition
6. Control systems
7. Safety

In conclusion, the top seven delay factors and the top seven success factors that have been found in the literature have been taken and formed as they are shown in the Figure 3.2. From now and on they will be referred to as the critical delay factors and critical success factors:

Success factors		Delay factors	
S1	Organization's planning efforts	D1	Owner's cash problems during construction
S2	Project manager's goal commitment	D2	Delays in contractor's progress payments by the owner
S3	Project team's motivation and goal orientation	D3	Slowness in the owner's decision making process
S4	Clarity of the project scope and work definition	D4	Contractor's financial problems during construction
S5	Project manager's capabilities and experience	D5	Design errors made by the designer
S6	Safety precautions and applied procedures	D6	Excessive bureaucracy in the owner's operation
S7	Use of a control system	D7	Changes in types or specifications of construction material

Figure 3-2 Critical Success and Delay Factors

4.0 METHODOLOGY

Based on the outcomes of previous studies, critical success and delay factors were identified. Saudi Arabian construction projects were used as a case study to examine the general correlation of critical success and delay factors. A diagram summarizing research methodology is presented in Figure 4.2.

METHODOLOGY OVERVIEW

This study methodology is based on the critical success and delay factors identified from the literature. Presented below are the data collection instruments designed to furnish the data required for answering the research questions, and the statistical analysis methods chosen for the analysis procedure.

4.1 CRITICAL SUCCESS AND DELAY FACTORS

As described in Chapter Three, the most critical success and delay factors have been chosen from the literature for further analysis in this study, as shown in Figure 3.2. The study will attempt to understand the relationship between these critical factors to improve the possibility of completing the construction projects as scheduled by identifying the most influential success factors that may avoid or prevent one or more of the delay factors.

#	Success factors	Delay factors
1	Organization’s planning efforts	Owner’s cash problems during construction
2	Project manager's goal commitment	Delays in contractor’s progress payments by the owner
3	Project team's motivation and goal orientation	Slowness in the owner's decision making process
4	Clarity of the project scope and work definition	Contractor’s financial problems during construction
5	Project manager's capabilities and experience	Design errors made by the designer
6	Safety precautions and applied procedures	Excessive bureaucracy in the owner’s operation
7	Use of a control system	Changes in types or specifications of construction material

Figure 4-1 Critical Success and Delay Factors

4.2 SURVEY INSTRUMENT

In the previous research, two types of surveys beside and interviews were used as data collection instruments. The target populations interviewed or surveyed were either related to a specific project as in (Ashley et al.1987) or came from general experience as in (Assaf et al.1995). In this study the two previous data collection techniques were applied, creating two types of surveys. A specific survey was created to collect data from those affiliated with a specific project, either owners or contractors. The general survey was created to gather information regarding individuals’ experiences with projects in general. A description of the surveys’ contents follows.

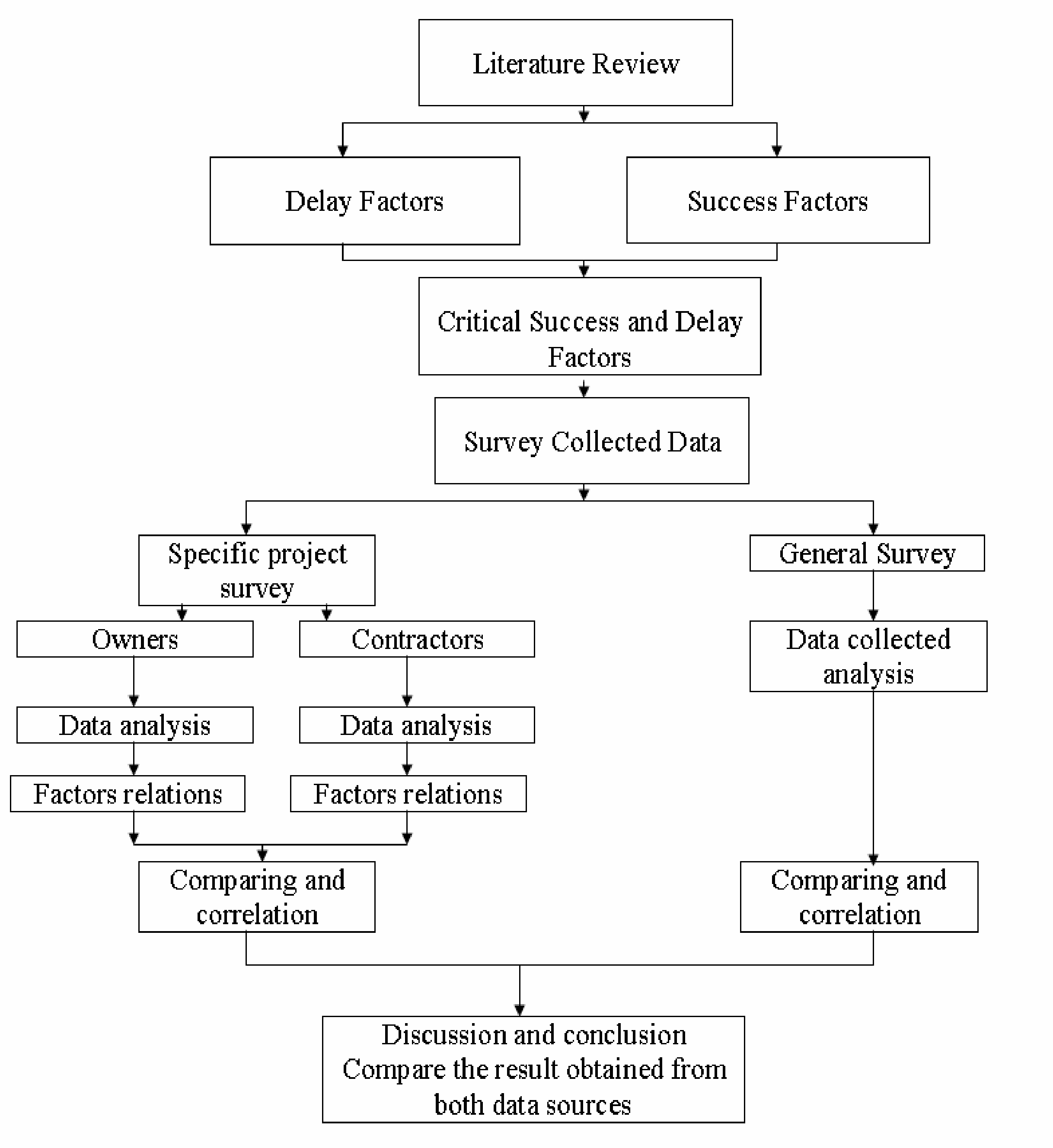

Figure 4-2 Research Methodology

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4.2.1 Specific Project Survey

A specific survey was designed to obtain recollections of exact field experiences from the specific project engineers. The target populations for this survey were owners and contractors, or their representatives who were involved in Saudi Arabian building and utility public projects. These projects must have been nearly completed, or completed within the last five years, and in order to gather necessary technical data, respondents were required to be project managers. This survey was designed in six parts:

4.2.1.1 Part One

Project information demographic questions such as the project location, type, planned cost, actually cost, planned duration, actually duration, contract type, and project designer. Such information helped to evaluate the project validity for this study.

4.2.1.2 Part Two

Owner's information, such as background and demographics (participants were also asked to voluntarily provide personal information such as their e-mail address or phone number, so that follow-ups could be conducted if required). To facilitate collection of any missing data, the owner's portion of the survey began with the demographic data of the participants; however, the researcher made it clear that the participants had to be engineers as this was the main basis for the research survey design. The respondents were assured about firm, engineer, and project data confidentiality. The engineer's data was required to give information about the respondent's knowledge and experience.

The types of questions in this part were: name of the project owners (in most cases these were government agencies), type of organization, owner's previous experience with a particular type of project, and availability of funding when the construction phase started. Other types of questions asked owners to evaluate work environment conditions such as the relationship among project team members, contractor's site engineer experience, and the contractor's financial position during the construction phase. These answers helped to clarify owners' evaluations of contractors who collaborated on the same project.

4.2.1.3 Part Three

Contract information, which includes demographic questions about the contractors, including name of the contractor, city, company category, whether payment was received from the owner on time as contracted or not, and how quickly the project owners made decisions.

Another type of question gave the contractor the ability to evaluate the project owner's characteristics, asking, for example, about the owner's cooperation and the working relationship among all the project team members.

4.2.1.4 Part Four

This section is concerned with the project's success and delay factor evaluations, and elicits respondents' opinions (either contractors or owners) about whether the project suffered from these delay factors or whether they applied any of the critical success factors. The evaluation scale was a five-point scale (very good = 5, good = 4, fair = 3, poor = 2, very poor = 1). At the end of this question, the respondent was given the opportunity to add any other success or delay factors they may have experienced in this project that were not listed. The answers for this section help to explain exactly how the project owners and the contractors evaluated the project.

4.2.1.5 Part Five

The relationship between success and delay factors consisted of seven questions. Every question asked about the presence of each of the delay factors and whether the project suffered from any or all of the top seven delay factors. If yes, the respondent was asked to provide answers about the influence of the top seven success factors listed and the mentioned delay factor. The evaluation scale of this question was also a five-point scale (completely = 5, a good deal = 4, a moderate amount = 3, a small amount = 2, and not at all = 1). For example, one of the questions asked to what extent the owner's cash problems during construction could have been avoided and/or prevented by a success factor (e.g., organization planning efforts). At the end of every question in this part, the respondent was given the opportunity to add any other success factors that could be used to avoid or prevent said delay factor.

4.2.1.6 Part Six

Additional causes of delay, where the respondent had the opportunity to add any cause of delay experienced in the project in addition to the top seven listed delay factors. Respondents were asked to evaluate these factors with the same 5-point scale mentioned in part 5 of this survey. Unfortunately this part did not produce any acceptable responses. None of the participants provided a response that indicated any new delay factors, ways that they could be avoided, or any new success factors that could avoid potential delay factors (a full version of the specific project survey can be found in Appendix H.

4.2.2 General Survey

The second version of the survey was created to gather expert opinions in a manner similar to the specific project survey. The target population was any engineer who worked or was still working in the Saudi Arabian construction field in at least the past five years. This survey consisted of three parts.

4.2.2.1 Part One

Engineer's information and general experience: This part consisted of three types of questions. The first type requested the engineer's demographic information (voluntarily) such as name, work location, academic major, qualifications, and employer, while the second type of question dealt with the engineer's experience. The third type of question had the engineer rate the quality of some of the contractors' and the owners' behavior based on the engineer's general experience in the construction field.

This included questions related to the typical working relationship among project team members, the typical level of cooperation of the owner or the owner's representatives, and the safety precautions generally applied by the owners and contractors.

4.2.2.2 Part Two

Project factors evaluation: In this section, the engineers were asked to evaluate construction project success and delay factors in general (this was similar to a question in the specific survey - Part Four). This part included questions such as, "Based on your overall professional experience in construction projects in Saudi Arabia in general, please evaluate the quality of the following project success or delay factors. Please add and evaluate any additional factors that you may have experienced to the list in the space provided." At the end of this question, the respondents were given an opportunity to add any other success or delay factors they may have encountered in their general experience, however very few participants added anything new. The answers to this question provided general knowledge about how success and delay factors were viewed in construction projects in Saudi Arabia. In this part, the same 5-point scale as in the specific project survey was used.

4.2.2.3 Part Three

The relationship between success and delay factors: This was similar to a question in the specific survey (Part Five) except that the data required were from the respondent's general experience, e.g., from your professional experience in the construction field, to what extent could an owner's cash problems during construction have been avoided and/or prevented by the factors listed below.

4.2.2.4 Part Four

Additional causes of delay: Respondents were given the opportunity to add any cause of delay in addition to the top seven delay factors already listed. They were also asked to evaluate the influence of the listed success factors on this additional delay factor, or any other new success factors that had been used to minimize the delay factor's effects using the same 5-point scale. No respondents provided any valuable new information. A full copy of the general survey can be found in Appendix I.

4.2.2.5 Glossary

Finally, in both survey versions the respondents were provided with a glossary of terms that could be used as a reference. This was to avoid personal interpretations, and provide participants with a common set of terms that could be more easily evaluated.

4.2.3 Sampling and Target Population

4.2.3.1 Sampling

Random sampling is the purest form of probability sampling. Each member of the population had an equal chance of being selected, provided the project's specific constraints were met. In contrast, the general survey explicitly sampled engineers with at least five years experience in the Saudi Arabian construction field.

4.2.3.2 Targeted Population

The specific project survey consisted of building and utility projects that were completed or partially completed within the past 5 years throughout Saudi Arabia. The general survey, however, was answered by any engineer with at least five years experience in Saudi Arabian construction projects.

4.2.4 Data Collection Channels

4.2.4.1 Internet

Two on-line surveys were designed: a specific and general survey, both with versions in English and Arabic depending on the respondent's preference.

4.2.4.2 Standard Mail

For the respondents who found it difficult to access the Internet, a hard copy was sent to them through standard mail.

4.2.5 Survey Procedures

4.2.5.1 Pilot Survey

A pilot survey was conducted in the early stages of the study in order to verify the quality and effectiveness of the questionnaire for both specific and general surveys. These pilot surveys were distributed in order to get feedback that could help the researcher improve the data collection strategy and also measure the exact time required to complete all questions, or identify any other problematic issues with the survey's format. The feedback received from the pilot survey was used to improve upon the final product. For example, on-line users found it hard to skip from one page to the next. This problem was minimized by eliminating unnecessary pages and every question was placed on one single page to reduce load times. No changes to the survey questions or format were made as result of the pilot testing.

4.2.5.2 Participation Arrangements

The necessary arrangements were made in advance with proposed target organizations (project owners), contractors, and the Saudi Council of Engineers in order to identify the sample population.

4.2.5.3 Time Scale

Each respondent was initially given three weeks to complete the survey, and then a reminder and an additional three weeks.

4.2.6 Receiving Data

In the case of the Internet based survey, the data was downloaded from the survey database.

4.2.7 Hard Copy Survey Collection

A colleague of the researcher acted as an intermediary, and his address was added to the contact information field of the survey's main page. This individual received all of the completed surveys and arranged for them to be mailed to the United States.

4.2.8 Data Coding

The collected data was prepared for coding in the following manner:

- Open ended questions such as additional comments were presented as text
- Categorical data: Numbers, like lump sum=1, unit price = 2, other = 3
- Interval level data: Numbers, for example "Was there an approved time extension for the project? If yes please specify length of extension ________ days."
- Ordinal level: Numbers like none= 1, little= 2, moderate amount = 3, and a lot = 4.
- Missing data: Was presented as a specific number, i.e., 999

4.3 STATISTICAL METHODS

As shown in the methodology chart (Figure 4.2), a separate analysis was prepared for every branch of data collected by using statistical analysis software (SPSS) including specific project contractors, specific project owners, and the general survey as an individual group, which was then compared between owners and contractors perceptions, and specific survey respondents with the general survey respondents. The following different types of statistical instruments were used in this study:

4.3.1 Pearson Correlation Coefficient

A Pearson correlation coefficient measures the strength and direction of the relationship between two quantitative variables. It ranges from -1 (perfect negative correlation) to +1 (perfect positive correlation). It is calculated by dividing the covariance of the variables by the square root of the product of their variance. Correlation is a measure of how two random variables X and Y "move" with respect to each other. Pearson's r is computed by:

$$r = \frac{\sum\left(X - \overline{X}\right)\times\left(Y - \overline{Y}\right)}{\sqrt{\sum\left(X - \overline{X}\right)^2 \times \left(Y - \overline{Y}\right)^2}}$$

In this study it was used to measure the strength and direction of the relationship between ratings of critical success and delay factors. In other words, are the evaluations of success factors related to evaluation of individual delay factors in the same project and from general perceptions? This method was used specifically to evaluate responses in part four of the specific survey and part two of the general survey.

Hypothesis testing: Pearson's correlation r is a sample statistic. To test if X and Y are significantly correlated in the population, we test the hypothesis that the population correlation coefficient, 'rho' (ρ) is significantly different from 0. For example, one of the hypotheses tested in the present study was that the correlation between success factor one and delay factor one was equal to 0.

H_0: $\rho = 0$

H_1: $\rho \neq 0$

The test statistic is given by:

$t_{test} = r\,(\sqrt{n-2})/(\sqrt{1-r^2})$

The critical value is $t_{critical}$ for a chosen significance level (α = 0.05) and (n – 2) degrees of freedom. The null hypothesis is rejected if $t_{test} > t_{critical.}$

4.3.2 Independent t test

The Independent Samples t test was used to compare the population means based on sample statistics from two independent populations. In this study a t test was used to compare owners' and contractors' perceptions of the influence of individual success factors on individual delay factors for specific projects.

Assumptions:

1) The dependent variable is normally distributed.

This assumption was not formally tested since the statistical literature has shown that the consequences of breaking this assumption are not serious, as long as sample sizes are not extremely small.

2) The two groups have approximately equal variance on the dependent variable.

The statistical software used to conduct analyses, SPSS, provides a test of this assumption and also provides results from a form of the t-test that does not assume equal variances in case there is evidence that the assumption is not met.

3) The two groups are independent of one another.

For this research study, the following generic non-directional hypotheses (two tailed) has been tested at a level of significance $\alpha = 0.05$.

H_0: $\mu_1 = \mu_2$

H_1: $\mu_1 \neq \mu_2$

Significance in this test is evaluated based on the *p*-value. A small *p*-value signifies that the test is significant and that a conclusion can be drawn from the results. For example if the *p*-value is greater than 0.05, the test is insignificant and no conclusions can be drawn.

4.3.3 One Way ANOVA

The statistical methodology for comparing the means of several populations is called analysis of variance, or simply ANOVA. ANOVA is a generalized test for the comparison of the means, whereas the z and t tests can be used to compare at most two groups. In this study one way ANOVA has been used to compare the mean ratings of the influence of the seven success factors on each of the delay factors in order to learn which success factors were seen as having the most influence. A separate analysis was carried out for owners, contractors, and engineers. The repeated measures form of ANOVA was used in this context because the same participants rated all seven of the success factors. In the between-subjects or independent groups' form of

ANOVA it is assumed that groups are independent, whereas in the repeated measures form a correlation between multiple measures of the same participants is assumed.

In ANOVA, we test the alternative hypothesis that at least one of the group means is different from the others, versus the null hypothesis that there is no difference between the means.

H_0: $\mu_1 = \mu_2 = \mu_3 = \ldots = \mu_{is}$

H_1: Not all the μ_is are equal

Assumptions of a one way repeated measures ANOVA:

- Dependent variable is normally distributed
- Independence of observations between subjects
- Homogeneity of variance across measures
- Homogeneity of covariance between pairs of measures

Figure 4.3 below shows one way ANOVA equations according to (Matlack, 1993).

Source	**Equation**	**F (test)**
Mean square treatment	$\frac{n_1(\bar{y}_1 - \bar{y})^2 + n_2(\bar{y}_2 - \bar{y})^2 + \ldots + n_K(\bar{y}_K - \bar{y})^2}{K-1}$	F= $\frac{MSTr}{MSE}$
Mean square error	$\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2 + \ldots + (n_K - 1)S_K^2}{N-K}$	
	Where N = total numbers of observations, K = number of groups n_i = sample size in each group, $\bar{y}_i$ = mean of group i $\bar{y}$ = overall mean , S_i^2 = variance of group I	

Figure 4-3 One Way ANOVA Equations

4.3.4 Two Way ANOVA

The two-way analysis of variance is an extension of the one-way analysis of variance. There are two independent variables, both of which are categorical. In this study two way ANOVA has been used for three purposes:

1) To compare the perceptions of owners and contractors regarding the relative influence of the seven success factors on each delay factor.

2) To compare the perceptions of owners, contractors, and engineers.

3) To compare the averaged perceptions of owners and contractors with respect to specific projects to the perceptions of engineers with respect to their overall general experience.

The form of two-way ANOVA used in the present study had one between-subjects factor (group) and one repeated or within-subjects factor (the seven success factors). The assumptions for this form of two-way ANOVA are the same as those for one-way repeated measures ANOVA, with the additional assumption of independence between groups.

Hypotheses

In general, there are three hypotheses tested by two-way ANOVA. These null hypotheses are given below.

- The population means of the first factor are equal.
- The population means of the second factor are equal.
- There is no interaction between the two factors.

In the present study, the first factor (the between subjects factor) was group, and the second factor (the repeated factor) was success factors. Therefore, the following three null hypotheses were tested:

- The population means of the groups are equal.

- The population means of the success factors are equal.
- There is no interaction between the effect of group and the effect of success factor.

H_0: $\mu_1 = \mu_2 = \mu_3 = \ldots = \mu_i$

H_1: Not all the μ_is are equal

Level of significance $\alpha = 0.05$

Source	**Sum of Squares**	**d.f.**	**Mean Square, MS**	**F**
Factor A: Difference between the a machine means $\bar{x}_i$	$SS_A = b\sum_{i=1}^{a}(\overline{X_{i.}} - \overline{\overline{X}})^2$	a – 1	$(SS_A / (a-1))$	$\frac{MS_A}{MS_E}$
Factor B : Difference between the b operator means $\bar{x}_{.j}$	$SS_B = \sum_{j=1}^{b}(\overline{X_{.j}} - \overline{\overline{X}})^2$	b -1	$MS_B = \frac{SS_B}{b-1}$	$\frac{MS_B}{MS_E}$
Residual (Error): difference between actual observation X_{ij} and fitted values $\hat{X}_{ij} = \overline{X}_i + \overline{X}_j - \overline{\overline{X}}$	$SS_B = \sum_{i=1}^{a}\sum_{j=1}^{b}(X_{ij} - \overline{X}_{i.} - \overline{X}_{.j} + \overline{\overline{X}})^2$	$(a-1)\times(b-1)$	$MS_E = \frac{SS_E}{(a-1)(b-1)}$	
Total	$SS_E = \sum_{i=1}^{a}\sum_{j=1}^{b}(X_{ij} - \overline{\overline{X}})^2$	$(ab-1)$		
Decision Rule: $F_A > F_{critical}$ $(\alpha = 0.05$, d.f. $(a-1)$, $(a-1)\times(b-1))$ $F_B > F_{critical}$ $(\alpha = 0.05$, d.f. $(b-1)$, $(a-1)\times(b-1))$				

Figure 4-4 Two Way ANOVA General Equations

4.3.5 Principal Components

a) The nature of principal components: If we have a single group of subjects measured on a set of variables, then principal components partitions the total variance by first finding the linear combination of the variables which accounts for the maximum amount of variance:

$$y_1 = a_{11}x_1 + a_{12}x_2 + ... + a_{1p}x_p$$

y_1 is called the first principal component, and if the coefficients are scaled such that $a_1'a_1 = 1$, where $a_1' = (a_{11}, a_{12}, ..., a_{1p})$ then the variance of y_1 is equal to the largest eigenvalue of the sample covariance matrix. (Morrison 1967). The coefficients of the principal components are the element of the eigenvector corresponding to the largest eigenvalue.

Then the procedure finds a second linear combination, uncorrelated with the first component, such that it accounts for the next largest amount of variance, this second component y_2 is:

$$y_2 = a_{21}x_1 + a_{22}x_2 + ... + a_{2p}x_p$$

The coefficients are scaled so that $a_2'a_2 = 1$, as for the first component. The fact that the two components are constructed to be uncorrelated means that the Pearson correlation between y_1 and y_2 is 0. The coefficients of the second component are simply the element of the eigenvector associated with the second largest eigenvalue of the covariance matrix, and the sample variance of y_2 is equal to the second largest eigenvalue.

The third principal component is constructed to be uncorrelated with the first two, and accounts for the third largest amount of variance in the system, and so on.

b) Applications of factor analysis: The main applications of factor analytic techniques are

- To reduce the number of variables.
- To detect structure in the relationships between variables, that is to classify variables, or, in other words, to form groupings or related variables. Therefore, factor analysis is applied as a data reduction or structure detection method.

In the present study, principal components analysis was applied to the ratings of the influence of the seven success factors on each of the seven delay factors. A separate principal components analysis was performed for each delay factor. These analyses were repeated for each of the three groups.

The output provided when principal components analysis is computed by a statistical package includes a table of factor loadings (correlations between variables and components). The recommended strategy for interpreting components is to first identify the variables that have relatively high loadings on a given component. Ideally, these variables should share a common idea; this common idea is used to "name" or "label" the component. Theoretically, the results of principal components analysis would serve to reduce the number of success factors in the present study. In the case of the present study, the results of principal components analysis did not provide meaningful insight for the following reasons. First, the composition of the components was different across the seven delay factors. Second, there was no obvious common idea shared by the success factors that had high loadings on the same component.

One likely reason why principal components analysis was not beneficial in the present study is that the sample size was too small. A rule of thumb states that there should be at least 10 subjects for every variable. To satisfy this rule, at least 70 subjects would have been needed (ten subjects by seven success factors). However, there were only 43 subjects in the largest group (engineers).

As stated earlier, data reduction and structure detection are the two primary motivations for conducting principal components analysis. In the present study, the goal of data reduction was already accomplished through the review of the literature, which identified the most critical success factors. A summary of the principal components results for owners, contractors, and engineers is in Appendix J.

4.4 ANALYSIS PROCEDURES

4.4.1 Specific Survey

Table 4.5 contains a descriptive summary of the statistical analysis procedures that were used for each part of the specific project survey:

- Part1 (project information): Frequencies and percentages is used to summarize responses.
- Part 2 (owner information): Frequencies and percentages is used to summarize responses to questions about type of organization, owner experience, and availability of funding. In the same manner, frequencies, percentages, and descriptive statistics were used to summarize owners' perceptions of contractors (means and standard deviations).
- Part 3 (contractor information): Frequencies and percentages is used to summarize responses to questions about project payments and approval of material samples. Frequencies, percentages, and descriptive statistics (means and standard deviations) used to summarize contractors' perceptions of the owners.
- Part 4 (Project factors evaluation): Pearson correlation coefficient is used to measure the strength and direction of the relationships between critical success and delay factors on the same projects. In addition, a t test was used to examine owners' and contractors' evaluation of projects' critical success and delay factors.
- Part 5 (Relationship between success and delay factors): Two-way ANOVA is used to examine the means differences between owners' and contractors' perceptions to determine exactly which critical success factors had the most influence in avoiding or preventing each delay factor.

Part #	Analysis Method and Description
Part 1	➢ Frequencies and percentages used to summarize responses
Part 2	➢ Frequencies & percentages used to summarize responses to questions about type of organization, owner experience, and availability of funding. ➢ Frequencies and percentages, and descriptive statistics used to summarize owners' perceptions of contractors.
Part 3	➢ Frequencies and percentages used to summarize responses to questions about project payments and approval of material samples. ➢ Frequencies and percentages, and descriptive statistics used to summarize contractors' perceptions of the owners.
Part 4	➢ Pearson correlation coefficient used to test for relationships between ratings of success factors and ratings of delay factors on the same projects. ➢ Used independent samples t-test to compare the mean for owners and contractors on success and delay factors evaluation.
Part 5	➢ For each delay factor, frequencies and percentages were reported for response options, means, and standard deviations for each success factor ➢ Used independent samples t-test to compare the mean for owners and contractors on the influence of each success factor on each delay factor (in case of one group) ➢ Used two-way ANOVA analysis of variance (in case of two and three groups)

Figure 4-5 Specific Project Survey Data Analysis Methods

4.4.2 General Survey

Figure 4.6 contains a descriptive summary of statistical analysis procedures that were used for each part of the general survey (engineers):

- Part 1 (Engineers information and general experience): Frequencies and percentages used to summarize background information about engineers. Frequencies and percentages and descriptive statistics (means and standard deviations) used to summarize engineers' perceptions of the characteristics of public projects.

- Part 2 (Project factors evaluation): Reported frequencies and percentages, means, and standard deviations for each success factor and each delay factor. This provided a view of how these factors were perceived by engineers with respect to projects in general. This also showed which success factors and which delay factors were experienced most commonly.
- Part 3 (Relationship between success and delay factors): For each delay factor, reported frequencies and percentages of response options, means, and standard deviations for each success factor. This showed which success factors the respondents saw as having the most influence on each delay factor by using a one-way ANOVA.

Part #	Analysis Method and Description
Part 1	➢ Frequencies and percentages used to summarize background information about engineers. ➢ Frequencies and percentages used and descriptive statistics to summarize engineers' perceptions of the projects characteristics.
Part 2	➢ Frequencies and percentages, means and standard deviations for each success factor and each delay factor.
Part 3	➢ For each delay factor, frequencies and percentages were reported for response options, means, and standard deviations for each success factor. ➢ For each delay factor, the mean rating of influence was listed for each success factor in order of highest to lowest. The rankings of the influence of the success factors were compared across the delay factors. ➢ One-way ANOVA analysis of variance.

Figure 4-6 General Survey Data Analysis Methods

5.0 RESULTS AND ANALYSIS

This chapter will present the characteristics of participants and the results of the Pearson correlation, t, and ANOVA tests carried out to answer the research questions.

5.1 INTRODUCTION

As described in chapter four, the sample for the study consisted of owners, contractors, and engineers involved in construction projects in the Kingdom of Saudi Arabia; engineers were given the general survey and asked to answer based on their general experience. Individual owners or contractors who worked on projects that had been constructed within the last five years took the specific project survey. This study collected data from both owners and contractors so that a comparison could be made between both parties. In addition, a comparison was made between the specific project perspective and the general experience perspective. The first perspective used the specific project data. This data had been collected from the parties directly involved with the project construction. Owners and contractors based their responses on a common project that they had contracted and completed. The second was a general perspective based on engineers' experience. The surveys were designed to collect data on the same critical success and delay factors from both sources.

5.1.1 Specific Project Survey: Owners and Contractors

The targeted owners and contractors received a total of 196 hard copy and electronic survey questionnaires, with 109 to the owners and 87 to the contractors. A total of 115 specific surveys were returned: 67 by owners (response rate 61.5%) and 48 by contractors (response rate 55.2%). Some effort was made to complete the missing data either by phone or over the research survey website. For specific surveys, 31 responses were received from both the owner and the contractor from a common project. In other words, there were 31 complete responses from the owners and 31 responses from the contractors on the same project, for a total of 62 completed surveys that qualified for analysis; the remaining 53 surveys were unqualified (36 owners, 17 contractors) for analysis since data was incomplete, or matching survey pairs were not received. Several attempts were made to follow up and complete surveys.

5.1.2 General Survey: Engineers

The second data resource was based upon engineers' general experience and not limited to a specific project. It was confirmed that 105 hard copy and electronic survey questionnaires had been received by the population of engineers working currently, or who had worked in the construction field in Saudi Arabia. The Saudi Council of Engineers database was utilized to reach the most experienced engineers in the country by inviting them to participate through the Saudi Council of Engineers Web site. By the deadline, 78 surveys were received (response rate 74.3%); 43 were completed and qualified for analysis, while the remaining surveys were missing data and incomplete

5.2 PARTICIPANTS' CHARACTERISITICS

5.2.1 Specific Project Survey

Thirty-one public project responses were received from owners and contractors who had been contracted on the same project. The descriptive statistics, characteristics, and information from the project owners and contractors are discussed here.

5.2.1.1 Project Information

- Project type: This aspect varied and included office buildings, residences, hospitals, schools, and mixed compounds, with a total of 31 projects. (48.4%) of the projects were mixed compounds, due to the nature of most public projects in Saudi Arabia, which require main buildings in addition to supporting buildings such as clinics, mosques, and maintenance facilities.
- Project area: In order to provide the same evaluation basis for all projects. The areas were categorized into three groups. The first group included projects up to 5,000 square meters, the second group included projects from 5,000 to 10,000 square meters, and the third group included projects larger than 10,000 square meters. The largest group (61.3%) in the sample was the third group.
- Project contract type: The sample contained only two types of contracts: lump sum contract (35.5%) and unit price contract (64.5%).

- Project designer: Projects which were designed in-house by the owner's engineering staff comprised 74.2%, of the sample, and projects designed by consultants comprised 25.8% of the sample.
- Project costs: The respondents were asked the difference between the projects' contracted cost and its actual cost, and it was found that 29% of the sample projects were over budget, 67.7% at budget, and 3.3% were under budget.
- Project duration: 58.1% of the projects were delayed with the length of delay ranging between 30 to 360 days, and 41.9% of the sample projects were finished on time.

5.2.1.2 Owners' Characteristics

- Owner's experience: 74.2% of the projects owners had extensive experience with these types of projects, the remaining owners had some experience, and none of the respondents were without experience.
- Owner's funding availability: 58.1% of the sample size had the required project funding completely available, and 41.9% had funding partially available.

The survey asked each of the contract parties to evaluate the relationships among project team members and other characteristics and behaviors that occurred during the project's construction period. The owners were asked to evaluate some of the contractors' quality and experience:

- The working relationship among the members of the project's team was rated on a scale where 5 = very good, 4 = good, 3 = fair, 2 = poor, and 1 = very poor. In the survey, 45.2% of the participants reported that the relationship among the project team (i.e., owner, consultants, and contractors' staff) was very good, 38.7% said relations were good, 12.9% fair and only one respondent (3.2%) responded that teamwork was poor. The sample mean was 4.26 out of 5, which is a good rating.

- The initiative of the contractor's site manager: On the survey, 25.8% of the participants evaluated the site managers' initiative as very good, 45.2% stated that it was good, 16.1% saw it as fair, 9.7% found it poor, and one respondent 3.2% evaluated the site manager's initiative as very poor. The sample mean was 3.81, which corresponds to good on the 5-point scale.
- The experience of the contractor's site engineers: On the survey, 32.3% saw the engineers' experience as very good, 48.4% as good, 12.9% as fair, and 6.2% were evaluated as poor. The sample mean was 4.06, corresponding to good on the instrument scale.
- The involvement of the contractor's site manager: The survey showed that 16.1% of participants thought site manager involvement was very good, 45.2% good, 32.3% fair, and 6.5% were evaluated as poor. The sample mean was 3.71, which is equivalent to good on the instrument scale.
- The contractor's financial position during the construction phase: Of the respondents, 22.6% evaluated the contractors' financial position as very good, 38.7% as good, 19.4% as fair, 16.1% as poor, and 3.2% as very poor. The mean of 3.60 shows that the sample contractors were seen to be in a good financial position during the construction phase.

5.2.1.3 Contractors' Characteristics

- Contractor category: In this study, 48.4% of the sample contractors were classified as first category, 41.9% were second category, and 9.7% were classified in the third category. The contactors' classification in Saudi Arabia begins in the first category, in which contractors are eligible to bid on any project for 5 million Saudi Riyals. The contractors' classification process in Saudi Arabia requires certain conditions in order to classify the companies, such as financial situation, balance sheets for the last 5 years, key workers' qualifications, and equipment and any other owned assets. Based on this distribution, it is clear that the contractor sample represented the medium class of contractors in Saudi Arabia, and all the sample members were classified such that all of them had the officially mandated requirements.

- Performance payments made on time: The survey showed that 32.3 % of the sample contractors received their payments at the scheduled time, and the remaining sample contractors experienced delays in their payment from the owners on intervals varying between 30-150 days from the scheduled date of payment.
- Time taken by owner to approve material samples or finished work in comparison with contract conditions: From the survey, it was seen that 12.9% of the participants thought the owners approved the materials and finished work more quickly than specified in the contract, 45.2% thought it was about the same as specified, and 41.9% thought it was longer than specified in the contract.
- The quality of support from the contractor's senior management: The survey showed that 45.2% of the sample size thought the support from their senior management was very good, 35.5% good, and 9.7%, 6.5%, and 3.2% found it fair, poor, and very poor, respectively. The mean of 4.12 represents good as based on the survey scale.
- The relationship among all the project team members (i.e., owner, consultants, and contractors' staff): The survey showed that 32.3% of the sample size thought that the relationship among all the project team members was very good, 54.8% good, 9.7% fair,

and 3.2% poor. In general, most thought the relationship was good as reflected by the average mean of 4.16.

- The cooperation of the owner or the owner's representative: In this study, 35.5% of the sample contractors thought the owner or representative's cooperation was very good, 48.4% good, and 16.1% fair. The average mean was 4.19, which is in the good range.

5.2.2 General Survey

As mentioned in chapter 3 of this study, this survey was intended to obtain the expert engineers' opinions on the same critical factors from their general professional experience. In this survey, 43 of the surveys were appropriate for analysis.

5.2.2.1 Engineer's Characteristics and Experience

- Engineer's information: Some business and experience information was requested to give the researcher the ability to clarify any unclear responses or to complete the missing data, which was very helpful in completing the 43 finished surveys.
- Engineer's academic major: The academic major of the respondent engineers was very important, allowing the researcher to determine whether the information provided could be depended on or not. From among the 43 respondent engineers, 55.8% were civil engineers, 4.7% were involved in construction management, 14% were architectural engineers, and 25.5% of the other engineers were in the electrical, mechanical, or urban design areas.
- Engineers' qualifications: The survey showed that 58.1% of the sample held bachelor's degrees, 30.2% held master's degrees, and 11.6% held PhDs.

- Engineers' experience: The sample varied from a minimum of 10 years, with the most experienced engineer in the sample having 35 years of experience. With average mean of 20 years experience.
- Engineer's site experience: Only 18.6% of the engineers stated that they had no experience as site engineers, and the remaining percentage had worked on at least 50 projects as site engineers.
- Engineer's experience as project manager: The survey showed that 70% of the sample size had worked as project mangers; most of them had worked at least on 60 projects as the project manager.

5.2.2.2 Engineer's Feedback

Engineers also were asked to give their opinions on some general project characteristics as listed below.

- The most successful method of construction project design: The survey analysis showed that 66.7% of the sample engineers thought that if the project was designed by a specialist consultant it would be more successful than if designed by other methods also used in public organizations in Saudi Arabia, many of which were designed by the organization's engineering department.
- The most successful type of project contracts: In the survey, 88.1% of the sample believed that unit price contracts were more successful than lump sum contracts.
- Influence of bureaucracy on the delay of construction projects in the Kingdom of Saudi Arabia: 48.8% of the engineers sampled thought that the bureaucracy had a very strong

influence, 32.6% a strong influence, 14% a moderate influence, 2.3% a weak influence, and 2.3% thought that that bureaucracy had no influence.

- Time taken by owner to approve material samples or finished work in comparison to contract conditions: 59.5% of the sample engineers thought that the owners took longer than specified in the contracts, and 40.5% thought it was about the same.
- Authority that the average project manager had in running a project: 4.7% of the sample thought that the project's engineer had complete authority, 58.1% thought the engineer had a great deal of authority, 27.9% said some authority, and 9.3% said the engineer had only a little authority.

5.2.2.3 Contract Parties' Relationships

Just as owners and contractors evaluated the common contract parties' behavior during the project construction period, engineers also responded to questions of a similar nature:

- The typical working relationship among project team members (owner, consultants, and contractors' staff): Most of the expert engineers (41%) thought that the relationship between the project team and the owners was good, 14% very good, 38% fair, and 7% poor.
- The typical level of cooperation of the owner or the owner's representatives: 40.5% were good, 7.1% very good, 38.1% fair, and 14.3% poor.
- Support for the project, from the typical contractor's senior management: 14% of the sample thought that the support was very good, 26% good, 31% fair, 26% poor, and 3% very poor.
- The safety precautions generally applied by the owners: 7.1% thought that the owners were very good, 33.3% good, 28.6% fair, 28.6% poor, and 2.4% very poor.

- The safety precautions generally applied by the contractors: 9.5% thought the safety precautions taken by the contractors were very good, 28.6% good, 33.3% fair, 26.2% poor, and 2.4% very poor.

5.3 ANALYSIS AND DISCUSSION

As mentioned in the previous two sections of this chapter, the specific survey intended to gather data from owners and contractors that collaborated on the same project, and then responded based upon their specific experiences with that project. On the other hand, the general survey was designed to collect data from engineers working in the Saudi construction industry in general, and their responses did not focus on any one project in particular. Respondents in both surveys possessed the title of engineer, however from this point the word 'engineers' will be in reference to general survey respondents only. The main goal of this chapter is to provide an explanation of the research questions, the hypotheses, the statistical analysis, and finally the conclusions as summarized in Figure 5.1.

This analysis focuses primarily on parts four and five of the specific project survey and parts two and three of the general surveys. The questionnaires are shown in Figures 5.2, 5.3, 5.4, and 5.5 respectively

	Research questions	Answer sought	Statistical method
1	How do specific critical success factors affect individual critical delay factors?	Measurement of the strength and direction of relationship between critical success and delay factors	A Pearson correlation coefficient was used for each group separately (owners, contractors, and engineers). Section 5.3.1
2	Do these relations vary by project affiliation (owner/ contractor?	Comparison of owners' means and contractors' perceptions in both evaluating success and delay factors and influence of success factors on each delay factor	A t - test examining owners' and contractors' evaluation of projects' critical success and delay factors and the influence of critical success factors on critical delay factors. Section 5.3.2
3	Does the ranking of the relative influence of the critical success factors on each critical delay factor vary by specific project respondents or general experience respondents?	Determine if the means differ between responses to the specific survey (owners and contractors) and responses to the general survey (engineers)	One and two-way ANOVA were used to examine the means differences. Section 5.3.3

Figure 5-1 Analysis and Discussion Content Summary

Part four in the specific project survey: Based on your experience with this project, please evaluate the overall quality of the following factors, and please add any other success or delay factors that you may have experienced in this project that are not included in this list					
Success factors	V. Good (5)	Good (4)	Fair (3)	Poor (2)	V. Poor (1)
Organization planning efforts.					
Goal commitment of the project manager.					
Motivation and goal orientation of the project team.					
Clarity of the project scope and work definition.					
Capability and experience of the project manager.					
Safety precautions and applied procedures.					
The control system used for this project.					
Delay factors	V. Good (5)	Good (4)	Fair (3)	Poor (2)	V. Poor (1)
Owner's cash availability during construction					
Timeliness of the owner's payments to the contractor					
Timeliness of decision making by owner					
Contractor's availability of funding during construction					
Design errors by designer					
Efficiency of project owner's operation (bureaucracy)					
Changes in types or specifications of construction material					

Figure 5-2 Part Four in the Specific Project Survey

Part five in the specific project survey: In this project, did the owner experience any cash problems (D1) during construction?
No__________ (if no, please skip to the next question) Yes ____________

If yes, to what extent could the owner's cash problems during construction have been avoided and/or prevented by the:

	Completely (5)	A good deal (4)	A moderate amount(3)	A small amount (2)	Not at All (1)
Organization's planning efforts.					
Project manager's goal commitment.					
Project team's motivation and goal orientation.					
Clarity of the project scope and work definition.					
Project manager's capabilities and experience.					
Safety precautions and applied procedures.					
Use of a control system.					
Other______________________					
Other______________________					

(This form has been repeated for all the seven critical delay factors)

Figure 5-3 Part Five in the Specific Project Survey

Part two in the general survey: Based on your overall professional experience in construction projects in Saudi Arabia, in general please evaluate the quality of the following project success or delay factors. Please add and evaluate any additional factors that you may have experienced to the list in the space provided					
Success factors	V. Good (5)	Good (4)	Fair (3)	Poor (2)	V. Poor (1)
Organization planning efforts.					
Goal commitment of the project manager.					
Motivation and goal orientation of the project team.					
Clarity of the project scope and work definition.					
Capability and experience of the project manager.					
Safety precautions and applied procedures.					
The control system used for this project.					
Delay factors	V. Good (5)	Good (4)	Fair (3)	Poor (2)	V. Poor (1)
Owner's cash availability during construction					
Timeliness of the owner's payments to the contractor					
Timeliness of decision making by owner					
Contractor's availability of funding during construction					
Design errors by designer					
Efficiency of project owner's operation (bureaucracy)					
Changes in types or specifications of construction material					

Figure 5-4 Part Two in the General Survey

Part three general survey: Below are a series of questions. Each set of items follows a similar format. In each set, you will be asked to indicate the extent to which one feature (delay factor) of the project could have been affected by several other project factors. There is a glossary provided at the end of this document to clarify terms.

1. From your professional experience in the construction field, to what extent could an owner's cash problems during construction have been avoided and/or prevented by the factors listed below … (If there are other factors that could have prevented cash problems, please list and evaluate in the spaces provided below).

	Compl etely	A good deal	A moderate amount	A small amount	Not at All
Organization planning efforts					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and work definition					
Project manager's capabilities and experience					
Safety precautions and applied procedures.					
Use of a control system.					
Other___________________________					
Other___________________________					

(This form has been repeated for all the seven critical delay factors)

Figure 5-5 Part Three in the General Survey

5.3.1 Research Question One

How do specific critical success factors affect individual critical delay factors?

Determining the relationship between critical success and delay factors in specific projects was one of the main goals of this study. In other words, one goal was to search for recurring appearances of specific success factors with certain delays. The analysis went one step further by comparing specific project respondents' (owners and contractors) correlation results with the general projects respondents' correlation results.

In order to answer this question, the project critical success and delay factors evaluation from the specific project survey (Part 4, Figure 5.2), and from the general survey (Part 2, Figure 5.4) were analyzed. The wording of the success and delay factors in those sections were changed from the original form (Figure 3.2) for both the specific and general surveys so that participants would have the latitude to express either positive or negative perceptions, based on their actual experiences through the elimination of suggestive phrasing in some questions. The change was necessary especially for delay factors, which were worded in a negative rather than natural way. For example delay factor 1, originally stated as "owner's cash problems during construction" was rephrased as, "Owner's cash availability during construction," as shown in Figure 5.6.

5.3.1.1 Statistical Method

Pearson correlation coefficient has been applied to measure the strength and direction of relationship between ratings of critical success and delay factors on the same project (specific project survey) and on the general survey - engineers' experience. The null hypothesis is that the correlation coefficient ρ is equal to zero. The alternative hypothesis is that ρ is not equal to zero at a significance level of $\alpha = 0.05$:

Hypothesis

H_0: $\rho = 0$

H_1: $\rho \neq 0$

$\alpha = 0.05$

Success factors		Delay factors	
S1	Organization planning efforts	D1	Owner's cash availability during construction
S2	Goal commitment of the project manager	D2	Timeliness of the owner's payments to the contractor
S3	Motivation and goal orientation of the project team	D3	Timeliness of decision making by the owner
S4	Clarity of the project scope and work definition	D4	Contractor's funding availability during construction
S5	Capability and experience of the project manager	D5	Design errors by the designer
S6	Safety precautions and applied procedures.	D6	Efficiency of project owner's operation (bureaucracy)
S7	The control system used for project	D7	Changes in types or specifications of construction material

Figure 5-6 Critical Success and Delay Factors

The following outlines the results from the examined groups:

5.3.1.2 Owners

As shown in Table 5.1 there was one significant correlation, which was a moderate positive correlation between the safety record (S6) and the efficiency of a project owner's operation (bureaucracy) (D6). Where $r = 0.380$, $p = 0.035$. At $\alpha = .05$ the null hypotheses is rejected and the conclusion was significant. One way of interpreting this is that a better safety record is associated with a more efficient project owner's operation (less bureaucracy).

Table 5-1 Correlation Coefficient - Success and Delay Factors by Owners

		D1	D2	D3	D4	D5	D6	D7
S1	r	-0.140	0.145	-0.135	0.080	-.212	-0.171	-0.042
	p	0.453	0.435	0.468	0.669	.261	0.359	0.831
S2	r	-0.313	-0.227	-0.092	-0.190	-.162	-0.051	-0.194
	p	0.086	0.220	0.623	0.306	.392	0.786	0.312
S3	r	-0.168	-0.153	0.256	-0.132	-.016	0.259	0.148
	p	0.367	0.410	0.165	0.479	.932	0.159	0.444
S4	r	0.262	-0.140	-0.096	0.112	-.324	-0.054	-0.204
	p	0.154	0.454	0.607	0.549	.081	0.771	0.288
S5	r	-0.023	0.002	-0.021	-0.008	-.174	0.095	-0.098
	p	0.904	0.993	0.912	0.968	.358	0.611	0.612
S6	r	0.041	-0.032	0.290	-0.067	-.007	0.380	0.035
	p	0.828	0.863	0.114	0.721	.970	0.035	0.857
S7	r	0.272	-0.197	-0.023	-0.285	-.034	0.028	-0.102
	p	0.146	0.298	0.903	0.127	.862	0.884	0.604
Correlation (r) is significant at $\alpha = 0.05$ level								

S1: Organization planning efforts S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of a control system	D1: Owner's cash problems during construction D2: Delays in contractor's progress payments by the owner D3: Slowness in the owner's decision making process D4: Contractor's financial problems during construction D5: Design errors made by the designer D6: Excessive bureaucracy in the owner's operation D7: Changes in types or specifications of construction material

5.3.1.3 Contractors

Table 5.2 shows that there were three significant moderate negative correlations between delays related to change in construction material types and specifications (D7), with each of the following success factors:

- Goal commitment of the project manager (S2) ($r = -0.516$, $p = 0.003$). The p-value was 0.003, less than a significance level of 0.01. Based on that the null hypothesis was rejected and the result was significant.
- Motivation and goal orientation of the project team (S3) ($r = -0.369$, $p = 0.04$). H_0 was rejected at a significance level of $\alpha = 0.05$.
- Clarity of the project scope and work definition (S4) ($r = -0.408$, $p=0.023$). H_0 was rejected at a significance level of $\alpha = 0.05$.

Contractors thought occurrences of the critical success factors (S2), (S3), and (S4) were associated with fewer delays related to changes in types or specifications of construction material (D7).

Table 5-2 Correlation coefficient - Success and Delay Factors by Contractors

		D1	D2	D3	D4	D5	D6	D7
S1	r	-0.057	-0.172	-0.061	-0.273	-0.128	0.054	-0.122
	p	0.762	0.354	0.744	0.138	0.494	0.773	0.514
S2	r	-0.198	-0.197	-0.336	-0.178	-0.028	-0.252	-0.516
	p	0.286	0.287	0.065	0.338	0.881	0.172	0.003
S3	r	0.018	-0.345	-0.161	-0.186	-0.056	-0.184	-0.369
	p	0.922	0.057	0.388	0.317	0.765	0.321	0.041
S4	r	-0.251	-0.267	-0.176	-0.083	-0.047	-0.136	-0.408
	p	0.174	0.146	0.344	0.657	0.800	0.467	0.023
S5	r	-0.044	-0.013	0.242	0.027	-0.022	0.023	-0.116
	p	0.814	0.946	0.189	0.885	0.908	0.901	0.533
S6	r	-0.192	-0.183	0.069	-0.068	0.299	0.195	-0.190
	p	0.302	0.324	0.712	0.718	0.103	0.294	0.306
S7	r	-0.033	-0.005	-0.024	-0.067	0.287	0.158	-0.188
	p	0.859	0.979	0.899	0.719	0.117	.0395	0.310

Correlation (r) is significant at $\alpha = 0.05$ level

S1: Organization planning efforts S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of a control system	D1: Owner’s cash problems during construction D2: Delays in contractor’s progress payments by the owner D3: Slowness in the owner's decision making process D4: Contractor’s financial problems during construction D5: Design errors made by the designer D6: Excessive bureaucracy in the owner’s operation D7: Changes in types or specifications of construction material

5.3.1.4 Engineers

As shown in Table 5.3 there are 26 significant correlations at $\alpha = 0.05$. (r and p values are listed in Table 5.3) some examples of the correlations between critical success and delay factors are:

- There are moderate positive correlations between organization planning efforts (S1) and all of the seven critical delay factors.
- Moderate positive correlation exists between the goal commitment of project manager (S2) and delays associated with the owner's cash availability (D1), timeliness of decision making by owner (D3), and contractor's funding availability during construction (D4).
- The presence of a moderate positive correlation between the clarity of project scope and work definition (S4), and with delays associated with owners' cash availability (D1) and design errors by the designer (D5).
- A moderate to strong positive correlation between the capability and experience of project manager (S5) and delays associated with owner's cash availability (D1), timeliness of decision making by owner (D3), contractor's funding availability (D4), and design errors by the designer (D5).
- A moderate positive correlation between safety record (S6) and delays associated with the owner's cash availability (D1), timeliness of owner's payments to contractor (D2), and contractor's funding availability (D4).
- A moderate to strong positive correlation is present between control system used for the project (S7) and all seven critical delay factors.

From the engineers' point view there are strong associations between both organization planning efforts (S1) and control system (S7) with all seven examined critical delay factors. In contrast, motivation and goal orientation of the project team (S3) had no significant correlation with any of the delay factors.

Table 5-3 Correlation coefficient - Success and Delay Factors by Engineers

		D1	D2	D3	D4	D5	D6	D7
S1	r	0.467	0.383	0.424	0.505	0.340	0.349	0.340
	p	0.002	0.012	0.005	0.001	0.028	0.023	0.027
S2	r	0.367	0.272	0.403	0.411	0.304	0.251	0.218
	p	0.017	0.081	0.008	0.007	0.050	0.109	0.166
S3	r	0.097	0.057	0.033	0.167	0.186	0.146	0.096
	p	0.541	0.720	0.833	0.290	0.239	0.357	0.547
S4	r	0.421	0.186	0.221	0.298	0.409	0.162	0.279
	p	0.005	0.237	0.159	0.056	0.007	0.305	0.074
S5	r	0.586	0.276	0.500	0.445	0.372	0.296	0.171
	p	0.000	0.077	0.001	0.003	0.015	0.057	0.278
S6	r	0.393	0.313	0.260	0.322	0.153	-0.157	0.191
	p	0.010	0.044	0.096	0.038	0.334	0.321	0.227
S7	r	0.569	0.411	0.422	0.478	0.434	0.310	0.414
	p	0.000	0.007	0.005	0.001	0.004	0.046	0.006

Correlation (r) is significant at $\alpha = 0.05$ level

S1: Organization planning efforts S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of a control system	D1: Owner's cash problems during construction D2: Delays in contractor's progress payments by the owner D3: Slowness in the owner's decision making process D4: Contractor's financial problems during construction D5: Design errors made by the designer D6: Excessive bureaucracy in the owner's operation D7: Changes in types or specifications of construction material

5.3.1.5 Conclusion

In the specific project, owners thought a superior safety record was associated with a more efficient project owner's operation (less bureaucracy), while contractors believed occurrences of the significant critical success factors (S2, S3, and S4) were associated with fewer delays related to changes in types or specifications of construction material (D7). From the engineers' point view there were strong associations between both organization planning efforts (S1) and control system (S7) with all seven examined critical delay factors. In contrast, motivation and goal orientation of the project team (S3) had no significant correlation with any of the delay factors.

There was a minimal correlation (one for owners and three for contractors) between specific project critical success and critical delay factors; in contrast the engineers had 26 cases of correlation. This is for a number of reasons: owner and contractor respondents were constrained to their experiences with a specific project, a small sample size, or some owners or contractors didn't believe that there should be a relationship between the critical success and delay factors, and their results reflected that. Conversely, general survey engineers exhibited the highest correlation between success and delay factors, since they tended to evaluate them based on their general experience without any specific projects' constraints or circumstances in mind.

It is worth noting that the correlation results for the specific project respondents' survey (owners and contractors) in Table 5.1 and 5.2 showed some negative correlations, whereas none of the engineers' correlation results (see table 5.3) exhibited negative results.

5.3.2 Research Question Two

Do the relationships between critical success and delay factors vary by project affiliation (owner/ contractor)? This question examines if there was any difference in how owners and contractors evaluated individual critical success factors, critical delay factors, and the influence of critical success factors on each delay factor. The data used in this section originates from Parts Four and Five of the specific project survey. See Figures 5.2 and 5.3.

5.3.2.1 Statistical Method

An independent sample t test was employed to compare owners and contractors' perceptions of critical success factors, critical delay factors, and influence of critical success factors on each of the seven critical delay factors in a specific project by comparing their respective response means. The null hypothesis is that the mean response for contractors equals the mean response for owners; the alternative hypothesis is that the mean responses of owners and contractors are not equal; and the significance level, $\alpha = 0.05$. Tables 5.4, 5.5, and 5.6 present the results of these t tests respectively. The means were five point scales where 5 = very good or completely, 4 = good or a good deal, 3 = fair or moderate amount, 2 = poor or small amount and 1 = very poor or not at all

5.3.2.2 Critical Success Factors

H_0: $\mu_{owners} = \mu_{contractors}$,

H_1: $\mu_{owners} \neq \mu_{contractors}$

$\alpha = 0.05$

Table 5.4 shows two significant differences of perception between owners and contractors. The first significant difference was that the mean for owners was higher than the mean for contractors, for Motivation and goal orientation of the project team (S3), indicating that owners thought (S3) was more important than contractors did ($t = 2.07$, $p<0.05$).

The second significant difference was when the contractors rated capability and experience of project manager (S5) higher than owners ($t = -2.72$, $p<0.001$). Detailed tables of all t-tests can be found in Appendix A.

Table 5-4 t test - Critical Success Factors - Owners and Contractors

	S1	S2	S3	S4	S5	S6	S7
Owners	3.96	3.80	3.32*	3.83	3.80 **	3.48	3.80
Contractors	4.12	3.96	2.74	3.93	4.35	3.41	3.67
Shaded: Significant, * (p <0.05), ** (p<0.01)							

Where:

- S1: Organization planning efforts
- S2: Project manager's goal commitment
- S3: Project team's motivation and goal orientation
- S4: Clarity of the project scope and work definition
- S5: Project manager's capabilities and experience
- S6: Safety precautions and applied procedures
- S7: Use of a control system

5.3.2.3 Critical Delay Factors

H_0: $\mu_{owners} = \mu_{contractors}$,

H_1: $\mu_{owners} \neq \mu_{contractors}$

$\alpha = 0.05$

There was one significant difference of perception between owners and contractors: owners evaluated owner's cash availability (D1) higher than contractors did ($t = 2.4$, $p = 0.017$). This is not surprising however, since owners were evaluating themselves. Table 5.5 provides a summary of the results; more detailed tables can be found in Appendix A.

Table 5-5 t test - Critical Delay Factors - owners and contractors

	D1	D2	D3	D4	D5	D6	D7
Owner	3.74*	3.83	3.54	3.96	3.16	3.29	3.51
Contractor	3.09	3.58	3.70	3.48	3.22	3.67	3.83
Shaded: Significant, $p<0.05$ at $\alpha = 0.05$							

Where
- D1: Owner's cash availability
- D2: Timeliness of owner's payments to contractor
- D3: Timeliness of decision making by owner
- D4: Contractor's funding availability
- D5: Design errors by designer
- D6: Efficiency of project owner's operation (bureaucracy)
- D7: Changes in types or specifications of construction material

5.3.2.4 Differences in the Influences of Success Factors on Delay Factors

$H_{0\text{ (for each delay factor)}}$: $\mu_{\text{success factor (n) for owners'}} = \mu_{\text{success factor (n) for contractors'}}$

$H_{1\text{ (for each delay factor)}}$: $\mu_{\text{success factor (n) for owners'}} \neq \mu_{\text{success factor (n) for contractors'}}$

$\alpha = 0.05$

Table 5.6 exemplifies that contractors perceived organization planning efforts (S1), where $t = -2.18$, $p = 0.038$, and goal commitment of project manager (S2) where $t = -2.24$, $p = 0.033$, as being more important in aiding timeliness of decision making by owner (D3) than owners did Similarly, contractors rated organization planning efforts (S1), $t = -3.92$, $p = 0.001$, goal commitment of project manager (S2), $t = -2.66$, $p = 0.013$, clarity of project scope and work definition (S4), $t = -2.87$, $p = 0.008$, and capability and experiences of project manager (S5), $t = -3.04$, $p = 0.005$; as more important in aiding efficiency of project owner's operation (less bureaucracy) (D6) than owners did. More detailed tables can be found in Appendix A.

Table 5-6 t test - Owners and Contractors - Influence of Success Factors on Delay Factors

		D1	D2	D3	D4	D5	D6	D7
S1	Owners	4.4444	3.9412	3.7000*	4.2778	3.8333	3.1111**	3.7647
	Contractors	4.5000	4.4444	4.3500	4.2500	4.4286	4.3158	4.3000
S2	Owners	3.8000	3.1765	2.9000*	3.2222	2.9167	3.0000*	2.9412
	Contractors	3.1667	3.4444	4.0000	3.0625	3.4286	4.0526	3.6000
S3	Owners	2.7000	2.5882	2.6000	3.0000	2.5000	2.7778	2.7059
	Contractors	2.5833	2.8148	3.0000	2.6250	2.6429	3.0000	2.5500
S4	Owners	3.5000	2.9412	3.3000	3.7222	3.1667	2.5556**	3.4118
	Contractors	3.4167	3.6296	4.0000	3.8125	4.0000	4.0000	3.9000
S5	Owners	4.0000	3.2353	3.6000	3.8333	3.0833	3.0000**	3.5882
	Contractors	3.8333	3.9259	4.2000	4.1250	3.7143	4.4211	4.3000
S6	Owners	3.5000	2.8824	3.2000	3.2778	3.2500	2.8889	3.5294
	Contractors	2.7500	3.2222	3.1500	3.1875	3.2143	3.2632	3.2000
S7	Owners	3.7000	3.2941	3.6000	3.5000	3.2727	3.3333	3.6471
	Contractors	3.2500	3.8519	3.7500	3.6875	3.5000	4.0526	3.7000

Shaded = significant: * ($p<0.05$), ** ($p<0.01$)

- S1: Organization planning efforts
- S2: Project manager's goal commitment
- S3: Project team's motivation and goal orientation
- S4: Clarity of the project scope and work definition
- S5: Project manager's capabilities and experience
- S6: Safety precautions and applied procedures
- S7: Use of a control system

- D1: Owner's cash availability
- D2: Timeliness of owner's payments to contractor
- D3: Timeliness of decision making by owner
- D4: Contractor's funding availability
- D5: Design errors by designer
- D6: Efficiency of project owner’s operation (bureaucracy)
- D7: Changes in types or specifications of construction material

5.3.2.5 Conclusion

The previous t test results show primarily agreement with some differences in how owners and contractors evaluated the relations between the critical success factors, critical delay factors, and influence of critical success factors in avoiding each critical delay factor. This could be attributable to a small sample size, or the fact that all respondents were engineers and they perceived the factors in the same way.

For the success factors' influence in avoiding critical delay factors, there were six significant correlations out of a possible 49 (see Table 5.6). This exemplifies that there is general agreement in most cases. The differences occur in two delays factors, (D3) and (D6). Both delay factors relate to the owner. The remedies for the delay, i.e., the success factors, are always evaluated higher by the contractors than the owners. For example, for (D3), timeliness of decision making by the owner, contractors believe that organization planning efforts (S1) and project management goal commitment (S2) will have a greater influence on (D3) than owners do. Since this is an owner-based delayed factor, contractors may be trying to implement a strategy that may have less of an effect than they would like. A similar mismatch in beliefs occurs for efficiency of a project owner's operation (bureaucracy) (D6), where contractors believed (S1, S2, S4, and S5) had a significantly greater influence than owners did.

Likewise, owners likely overrated project team's motivation and goal orientation (S3) more so than contractors did. In conclusion, both parties (owners and contractors) tended to evaluate factors related to their own direct interests more highly than the other party.

For delay factor D1, where owner's cash availability was evaluated as "good" by owners and "fair" by contractors, contractors may have evaluated the situation from their perspective and without in-depth knowledge of the owner's cash position but with experience of the effect of owner’s cash availability regarding the planned budget and payment schedule. The availability of owner’s cash was not the main concern in this situation, but whether or not it was available to spend on the project.

For the critical success factors owners believed that project team's motivation and goal orientation (S3) was fair to good, while contractors thought it was fair to poor. This difference may be explained by the level of involvement in the project, with contractors more involved than owners.

5.3.3 Research Question Three – Individual Group

Does the ranking of the relative influence of the critical success factors on each critical delay factor vary by specific project respondents or general experience respondents?

To answer this section’s primary question, it was necessary to examine respondents’ data from a number of different perspectives, which meant combining or isolating certain groups’ results with others. This was done in the following ways:

- Owners, contractors and engineers were examined at individually in order to determine which critical success factors they perceived to be most influential in avoiding or preventing each delay factor.
- Owners and contractors were examined collectively to reveal which success factors they perceived most critical in avoiding or preventing each delay factor; these findings reflected the views of specific project survey respondents.
- Owners, contractors, and engineers were collectively examined in order to discover which critical success factors were most helpful in preventing each delay factor; this point of view reflected all three groups combined.

- Average of specific project respondents and engineers: This examination should indicate which critical success factors were most influential in avoiding or preventing each critical delay factor from the point view of specific project participants when compared to the general experience group.

The data analyzed to answer this research question originated from part five of the specific survey (see Figure 5.3), and part three of the general survey (see Figure 5.5), which gathered the respondents' opinions of which critical success factors were most effective in avoidance of some or all of the delay factors. Here are two example questions given to respondents; similarly formed questions were used for each delay factor:

- Specific project survey**:** In this project, did the owner experience any cash problems during construction (yes/no)? If yes, to what extent could the owner's cash problems during construction have been avoided and/or prevented by the seven listed critical success factors?
- General survey: From your professional experience in the construction field, to what extent could an owner's cash problems during construction have been avoided and/or prevented by the seven listed critical success factors.

Success factors		Delay factors	
S1	Organization's planning efforts	D1	Owner's cash problems during construction
S2	Project manager's goal commitment	D2	Delays in contractor's progress payments by the owner
S3	Project team's motivation and goal orientation	D3	Slowness in the owner's decision making process
S4	Clarity of the project scope and work definition	D4	Contractor's financial problems during construction
S5	Project manager's capabilities and experience	D5	Design errors made by the designer
S6	Safety precautions and applied procedures	D6	Excessive bureaucracy in the owner's operation
S7	Use of a control system	D7	Changes in types or specifications of construction material

Figure 5-7 Critical Success and Delay Factors

5.3.3.1 Owners

STATISTICAL METHOD

A one-way ANOVA was used to individually determine the owners' perceptions of the seven critical success factors' relative influence on each critical delay factor, through comparison of the critical success factors' means. Likewise the remaining group, contractors and engineers, were analyzed using the same statistical method (one way ANOVA). The null hypothesis is that the mean responses for the seven success factors are equal; the alternative hypothesis is that the mean responses are not equal.

H_0: $\mu_{S1} = \mu_{S2} = \mu_{S3} = \ldots = \mu_{S7}$

H_1: not all the μ_S are equal

Significance level $\alpha = 0.05$

In this section data will be presented for each groups' analysis by providing a general description of the group test, along with which success factors were found to be most influential in avoiding each delay factor. Post-hoc examination was carried out to determine which success factor was most significant at avoiding the same delay factors.

RESULTS DESCRIPTION

Owners evaluated the influence of success factors in avoiding or preventing delay factors to develop a clearer vision of which success factor is most influential in avoiding or preventing one or more of the delay factors. As shown in the tables below, beginning with Table 5.7, the group (owners) evaluation required data results such as mean, standard deviation, and group size (n) were extracted from SPSS output, which outputted and tabulated the data in Table 5.8. Data was then sorted by mean from highest to lowest; from this sorting, the final hierarchy lists for all the delay factors were combined together to form Table 5.9, which will be referred to as the data table from now on and in all testing groups.

Success factors were evaluated by their ability to avoid or prevent delay factor one (owner's cash problems during construction) by 31 owners who were asked the following question: "In this project, did the owner experience any cash problems during construction (yes/no)? If yes, to what extent could the owner's cash problems during construction have been avoided and/or prevented by the seven listed critical success factors?" Of the 31 respondents (n = 9) answered yes, all of whom experienced this delay factor first-hand during construction projects.

As illustrated in the last column of Table 5.7, critical success factors were sorted based on their means from maximum to minimum depending on their ability to avoid delay factor one, beginning with the most influential (S1), to the least (S3) as follows: (S1, S5, S7, S4, S6, S2, and S3). Similarly, Table 5.8 shows the ranking of all success factors for each delay factor.

Table 5-7 One way ANOVA results for owner

Owner's cash problems during construction					
	Mean	Std D.	n	Sort	Rank
S1	4.4444	0.52705	9	4.4444	S1
S2	3.6667	1.11803	9	4.3333	S5
S3	2.8889	1.26930	9	4.0000	S7
S4	3.7778	0.97183	9	3.7778	S4
S5	4.3333	0.70711	9	3.7778	S6
S6	3.7778	0.66667	9	3.6667	S2
S7	4.0000	0.50000	9	2.8889	S3
Data Direction →					

Table 5-8 One Way ANOVA Results for Owners

Delay 1							Delay 2					
	Mean	St.D.	n	Sort	Rank			Mean	St.D.	n	Sort	Rank
S1	4.4444	.52705	9	4.4444	1		S1	3.9412	.89935	17	3.9412	1
S2	3.6667	1.11803	9	4.3333	5		S2	3.1765	1.28624	17	3.2941	7
S3	2.8889	1.26930	9	4.0000	7		S3	2.5882	1.27764	17	3.2353	5
S4	3.7778	.97183	9	3.7778	4		S4	2.9412	1.24853	17	3.1765	2
S5	4.3333	.70711	9	3.7778	6		S5	3.2353	1.14725	17	2.9412	4
S6	3.7778	.66667	9	3.6667	2		S6	2.8824	1.11144	17	2.8824	6
S7	4.0000	.50000	9	2.8889	3		S7	3.2941	1.57181	17	2.5882	3
Delay 3							Delay 4					
S1	3.7000	1.05935	10	3.7000	1		S1	4.2778	.89479	18	4.2778	1
S2	2.9000	1.66333	10	3.6000	5		S2	3.2222	1.06027	18	3.8333	5
S3	2.6000	1.07497	10	3.6000	7		S3	3.0000	1.28338	18	3.7222	4
S4	3.3000	1.05935	10	3.3000	4		S4	3.7222	1.27443	18	3.5000	7
S5	3.6000	1.07497	10	3.2000	6		S5	3.8333	1.20049	18	3.2778	6
S6	3.2000	.78881	10	2.9000	2		S6	3.2778	1.12749	18	3.2222	2
S7	3.6000	.84327	10	2.6000	3		S7	3.5000	1.15045	18	3.0000	3
Delay 5							Delay 6					
S1	3.7273	1.00905	11	3.7273	1		S1	3.1111	0.92796	9	3.3333	7
S2	3.0000	1.09545	11	3.2727	7		S2	3.0000	1.11803	9	3.1111	1
S3	2.6364	1.12006	11	3.1818	5		S3	2.7778	1.20185	9	3.0000	2
S4	3.0000	1.09545	11	3.1818	6		S4	2.5556	1.01379	9	3.0000	5
S5	3.1818	1.16775	11	3.0000	2		S5	3.0000	1.11803	9	2.8889	6
S6	3.1818	.87386	11	3.0000	4		S6	2.8889	1.16667	9	2.7778	3
S7	3.2727	1.10371	11	2.6364	3		S7	3.3333	1.11803	9	2.5556	4
Delay 7												
S1	3.7647	1.14725	17	3.7647	1							
S2	2.9412	.96635	17	3.6471	7							
S3	2.7059	.91956	17	3.5882	5							
S4	3.4118	1.17574	17	3.5294	6							
S5	3.5882	1.27764	17	3.4118	4							
S6	3.5294	.94324	17	2.9412	2							
S7	3.6471	1.16946	17	2.7059	3							

Table 5-9 One Way ANOVA Summary Results for Owners

	D1	D2	D3	D4	D5	D6	D7
	Highest						
S	1	1	1	$1^{(3)*}$	1	7	$1^{(2)}$
S	5	7	5	5	7	1	7
S	7	5	7	4	5	2	5
S	4	2	4	7	6	5	6
S	6	4	6	6	2	6	4
S	2	6	2	2	4	3	2
S	3	3	3	3	3	4	3
	Least						

* $x^{(y)}$ means that there are significant differences between two success factors on the same delay factor, x success factor is more influential than y success factor in avoiding the same delay factor (i.e. organization planning efforts (S1) were of greater influence than project team motivation (S3) in avoiding contractor's financial problems during construction (D4).

S1: Organization planning efforts
S2: Project manager's goal commitment
S3: Project team's motivation and goal orientation
S4: Clarity of the project scope and work definition
S5: Project manager's capabilities and experience
S6: Safety precautions and applied procedures
S7: Use of a control system

D1: Owner's cash problems during construction
D2: Delays in contractor's progress payments by the owner
D3: Slowness in the owner's decision making process
D4: Contractor's financial problems during construction
D5: Design errors made by the designer
D6: Excessive bureaucracy in the owner's operation
D7: Changes in types or specifications of construction material

POST –HOC EXAMINATION

To determine precisely which success factor is most influential at avoiding or preventing this delay factor, Post-hoc examination was conducted. In this group (owners) Post-hoc examination at (α = 0.05) comparisons reveals significant difference between organization planning efforts (S1) and the lowest evaluated factor, project team's motivation and goal orientation (S3) in the avoidance of contractor’s financial problems during construction (D4) with a significant difference *(*p-value = 0.042). This indicates that organization planning efforts (S1) was more influential in avoiding contractor’s financial problems during construction (D4) than project team's motivation and goal orientation (S3). A similar relationship can be observed between organization planning efforts (S1), which was more influential in avoiding changes in types or specifications of construction material (D7) than project manger goal commitment (S2). More detailed tables can be found in Appendix B.

Table 5-10 One Way ANOVA Results for Owners (Post –Hoc)

Delay	(I) Success Factor	(J) Success Factor	Mean Difference (I-J)	(p)
D4	1	3	1.278*	0.042
D7	1	2	0.824*	0.014
* The mean difference is significant at the 0.05 level.				

CONCLUSION

As shown in the summary provided in Table 5.10, owners rated organization planning efforts (S1) most influential in avoiding all delay factors except preventing excessive bureaucracy in owner's operation (D6), where the use of control system (S7) was rated most influential. Project manager's capabilities and experience (S5), as well as use of control system (S7) alternated in the second and third rank at avoiding most of the delay factors. Clarity of the project scope and work definition (S4) varied in its effect on the delay factors, and fell to the third most influential success factor at avoiding (D4). In some cases (D6), it also fell to the least influential success factor. Lastly, project team's motivation and goal orientation (S3) was rated as having the least influence.

Owners' ranking of success factors was rarely statistically significant. With only two cases of significance between rankings of success factors influence on delay, we conclude that owners in general hold a broad set of option regarding the relationship of success and delay factors.

5.3.3.2 Contractors

RESULTS DESCRIPTION

Using the same procedure as for owners, contractor's evaluations were sorted by their means to determine which success factor was most influential in avoiding or preventing one or more of the delay factors. From Table 5.11 one can clearly notice that contractors thought organizational planning efforts (S1) was the most influential factor at avoiding all delay factors except excessive bureaucracy in the owner's operation (D6), which could be best avoided by project manager's capabilities and experience (S5). In other words, contractors believed owner's bureaucracy (D6) could be more easily avoided with the project manager's capabilities and experience (S5) rather than through organizational planning efforts. Project manager's capabilities and experience (S5) generally fell to the second rank at avoiding most of the delay factors. (S2, S4, and S7) alternate in position for the third, fourth and fifth ranks. However when compared to owners, contractors consistently ranked clarity of the project scope and work definition (S4) as more influential. Finally, the least effective success factors, safety precautions and applied procedures (S6), and project team's motivation and goal orientation (S3) fell into the last two categories.

POST –HOC EXAMINATION

Post-hoc was applied in order to determine where there were significant differences between the success factors in avoiding a delay factor. In the contractors group, all the critical delay factors had significance between the critical success factors except design errors made by designer (D5).

The most consistent results are that organization planning efforts (S1) and project manager's capabilities and experience (S5) have the most significant differences with other success factors. (S1) and (S5) were consistently significantly better than S3 and S6 in avoiding delay, with the exception of (D5). Detailed post–hoc tables for contractors can be found in Appendix C.

Table 5-11 One way ANOVA Results for Contractors

	D1	D2	D3	D4	D5	D6	D7
	Highest						
S	$1^{(2,3,6)*}$	$1^{(2,3,6)}$	$1^{(3,6)}$	$1^{(3,6)}$	1	$5^{(3,6)}$	$1^{(3,6)}$
S	$5^{(3,6)}$	$5^{(3,6)}$	$5^{(3,6)}$	$5^{(3)}$	4	$1^{(3,6)}$	$5^{(2,3,6)}$
S	$4^{(3)}$	$7^{(3,6)}$	$2^{(3)}$	4	5	2	$4^{(3)}$
S	$7^{(3,6)}$	$4^{(3)}$	$4^{(3)}$	7	7	7	7
S	2	2	7	6	2	4	$2^{(3)}$
S	6	6	6	2	6	6	6
S	3	3	3	3	3	3	3
	Least						

* $x^{(y)}$ means that there are significant differences between two success factors on the same delay factor, x success factor is more influential than y success factor in avoiding the same delay factor

S1: Organization planning efforts S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of a control system	D1: Owner’s cash problems during construction D2: Delays in contractor’s progress payments by the owner D3: Slowness in the owner's decision making process D4: Contractor’s financial problems during construction D5: Design errors made by the designer D6: Excessive bureaucracy in the owner’s operation D7: Changes in types or specifications of construction material

5.3.3.3 Engineers

RESULTS DESCRIPTION

For this group the success factors sorted by their means are shown in Table 5.12. Engineers felt that (S1), Organization planning efforts was more influential at avoiding all the delay factors except for delays associated with owner's cash problems (D1), delays in contractor's progress payment by owner's (D2), contractor's financial problems (D4), and design errors made by designer (D5). Although still ranked consistently high by engineers, this differs from the owners and contractors, who rated this success factor as the highest, with the exception of one delay factor. Engineers' thought that the project manager's capabilities and experience (S5) was most effective in preventing slowness in the owner's decision making process (D3), as well as excessive bureaucracy in the owner's operation (D6). Engineers strongly believed in the effectiveness of project scope and work definition (S4) in the avoidance of delays related to changes in types or specifications of construction material (D7). Finally, safety precautions and applied procedures (S6) and project team's motivation and goal orientation (S3) were rated as the least influential success factors for all seven delay factors, however not in a consistent manner as in the two previous cases involving owners and contractors. Success factors (S1), (S5), and (S7) are in most consistently in the top three ranks for all delay factors with (S4) occurring 3 times and (S2) twice.

POST –HOC EXAMINATION

There was a great deal of significance between the rankings of critical success factors at avoiding the same critical delay factor. For example, for owner's cash problems (D1), there was a significant difference between organization planning efforts (S1) and all of the other success factors except for project manager's capabilities and experience (S5), which could be due to a high standard deviation, and a large mean variance. (S1) was significantly different than (S2), (S3), (S5), and (S6) for delay (D5). The top three ranked success factors were almost always significantly better at avoiding delay than (S3), (S6), or both. Additional details of Post-hoc examinations can be found in Appendix D.

Table 5-12 One Way ANOVA Results for Engineers

	D1	D2	D3	D4	D5	D6	D7
	Highest						
S	$1^{(2,3,4,6,7)}$*	$1^{(3,6)}$	$5^{(3,6)}$	$1^{(3,6)}$	$1^{(2,3,5,6)}$	$5^{(3,6)}$	$4^{(2,3)}$
S	$7^{(3,6)}$	$5^{(3,6)}$	$4^{(3,6)}$	$7^{(6)}$	$7^{(6)}$	$1^{(6)}$	$5^{(3)}$
S	$5^{(3,6)}$	$7^{(3,6)}$	$1^{(3,6)}$	2	4	$2^{(3,6)}$	$1^{(2,3)}$
S	2	$2^{(3,6)}$	$2^{(3,6)}$	4	5	$4^{(6)}$	7
S	4	4	7	5	2	7	6
S	6	6	3	3	3	6	2
S	3	3	6	6	6	3	3
	Least						

* $x^{(y)}$ means that there are significant differences between two success factors on the same delay factor, x success factor is more influential than y success factor in avoiding the same delay factor

S1: Organization planning efforts S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of a control system	D1: Owner's cash problems during construction D2: Delays in contractor's progress payments by the owner D3: Slowness in the owner's decision making process D4: Contractor's financial problems during construction D5: Design errors made by the designer D6: Excessive bureaucracy in the owner's operation D7: Changes in types or specifications of construction material

5.3.3.4 Conclusion

Testing each respondent's group separately using a one-way ANOVA revealed some agreement between owners and contractors, especially for the most critical success factors' influences. It is clear that organization planning efforts (S1) was the most influential success factor for all groups, and there was strong agreement between owners and contractors that project team's motivation and goal orientation (S3) was the least influential success factor. Engineers showed general agreement with owners and contractors, however their data was less obvious, and exhibited more patterned results.

Owners and contractors differed regarding which success factor was most influential in helping to avoid excessive bureaucracy in the owner's operation (D6); they unanimously agreed that organization planning efforts were not the first important success factor in avoiding excessive bureaucracy in the owner's operation. Owners believed that use of a good control system (S7) would help to remedy this delay, while contractors felt project manager's capabilities and experience (S5) was influential, agrees with t test results, when contractors evaluated (S5) higher than owners (Table 5.4) likely reflecting their professional experience and trust they instill in the project manager. On the other hand, owners tend to view problems from a top down approach, and are not solely focused on the project construction process. Engineers confirmed the contractors' opinion that the project manager's capability (S5) could be more influential than organization planning efforts (S1).

When compared to contractors and engineers, safety precautions and applied procedures (S6) received the highest rating from owners, which can be seen in its ranking fourth twice regarding its ability to remedy design errors made by designer (D5), and changes in types or specification of construction materials (D7). In the fifth rank, safety precautions and applied procedures are associated with avoiding (D1, D3, D4, and D6). Finally, it is listed in the sixth rank at avoiding (D2). For the other two groups, contractors and engineers, (S6) was generally ranked in the sixth and seventh ranks. This may be because owners take safety precautions more seriously, since they are concerned about the potential delays caused by safety mishaps. Additionally, the nature of their work causes them to be concerned with safety, especially when one factors in the general definition of safety precautions as supplied in the survey's glossary of terms; safety precautions are, "All aspects of safety, with particular reference to the implementation of safety programs, monitoring of safety, safety regulations and requirements written into contract documents, and safety-linked bonus schemes."

While owners and contractors showed consistency in their ranking of success factors' influence, engineers rankings varied somewhat. Generally the three groups were in agreement regarding the greatest and least influential success factors at avoiding delay factors, with minor agreement in the middle range.

Contractors and engineers Post-hoc results showed more significance in the ranking of critical success factors than the owner's results (see Post-hoc results at Appendix B, C, and D). This may be because contractors and engineers were closer to the project process environment, and therefore possessed a clearer knowledge of the field and construction process than owners did.

5.3.4 Research Question Three – Combined Groups

This test was conducted in order to compare the responses of all groups, and involved conducting three separate groups of two way ANOVA tests. These tests examined differences among groups: owners and contractors, owners, contractors, and engineers, average owners and contractors with engineers in order to pinpoint the perception of relative influence for the seven critical success factors on each individual critical delay factor by comparing the means. The data used for this analysis was part five of the specific survey, and part three of the general survey (see Figure 5.3 and 5.5 respectively).

STATISTICAL METHOD - TWO WAY ANOVA

Critical factors relationships were tested between the groups by using a two-way analysis of variance (ANOVA), which compared how the groups perceived the relative influence of all seven critical success and delay factors by comparing their means. In order to determine which factors they believed most influential in preventing each delay factor, this test also examined the success factors effect, main group effect, and group by success factors (interaction), which are defined as:

- Success Factors Effect: This test examined whether or not the two groups as a whole thought some success factors had more or less influence than others to prevent or avoid each of the seven delay factors, which can be observed through post-hoc analysis.

The null hypothesis is that the mean responses for the seven success factors are equal; the alternative hypothesis is that the mean responses are not equal for each participating group:

H_0: $\mu_{S1} = \mu_{S2} = \mu_{S3} = \ldots = \mu_{S7}$

H_1: not all the μ_S are equal

Significance level $\alpha = 0.05$

- Group Main Effect**:** Does one group (i.e. owners vs. contractors) think that the success factors as a whole, i.e., the seven success factors together, have more influence than the other group on each of the seven delay factors?

H_0: $[(\mu_{S1\ owners} + \mu_{S2\ owners} + \ldots + \mu_{S7\ owners}) / 7] = [(\mu_{S1\ contractors} + \mu_{S2\ contractors} + \ldots + \mu_{S7\ contractors})/7]$

H_1: $[(\mu_{S1\ owners} + \mu_{S2\ owners} + \ldots + \mu_{S7\ owners}) / 7] \neq [(\mu_{S1\ contractors} + \mu_{S2\ contractors} + \ldots + \mu_{S7\ contractors})/7]$

Significance level $\alpha = 0.05$

- Group by Success Factors (Interaction): Are the rankings of success factors for a particular delay different or the same across the two groups? If the rankings are very similar, the interaction will not be significant.

The null hypothesis is the rank for success factors between two groups are equal; the alternative hypothesis is the rank not equal. For each delay factor (D1, to D7):

H_0: $Rank_{S1\ owners} = Rank_{S1\ contractors}$, ….., $Rank_{S7\ owners} = Rank_{S7\ contractors}$

H_1: $Rank_{S1\ owners'} \neq Rank_{S1\ contractors}$, ….., $Rank_{S7\ owners} \neq Rank_{S7\ contractors}$

Significance level $\alpha = 0.05$

5.3.4.1 Owners and Contractors

As stated earlier, the aim is to gather the opinions of the response groups individually, as well as collectively in order to examine their similarities and differences, which could then lead to a more detailed examination of the relationship between success and delay factors. In this section, data from the tests and their results will be presented in the form of results descriptions, success factors effect, group main effect, interaction, and a conclusion for all of the groups' cases. Details Tabled can be found in Appendix E

RESULTS DESCRIPTION

By examining the two groups' data collectively, the summary of the main tests in Figure 5.8 showed that there is a success factors main effect for all success factors in avoiding most delay factors, except for (D6). There was group main effect for (D6) and one group by factors interaction for (D7). An examination of the two way ANOVA results in Table 5.13 not only shows that certain critical success factors were seen as having a greater influence in preventing individual critical delay factors, but that the pattern of results was very similar across all seven delay factors. Specifically, respondents indicated that organization planning efforts (S1) and project manager's capabilities and experience (S5) are the most influential factors in preventing nearly all seven delay factors. Similarly, project team's motivation and goal orientation (S3) was seen as the least influential factor in preventing the seven delay factors.

Source	D1	D2	D3	D4	D5	D6	D7
Success factors	Yes	Yes	Yes	Yes	Yes	No	Yes
Group	No	No	No	No	No	Yes	No
Interaction	No	No	No	No	No	No	Yes

Figure 5-8 Two-Way ANOVA Analysis Results Summary for Owners and Contractors

Table 5-13 Two Way ANOVA Results for Owners and Contractors

	D1	D2	D3	D4	D5	D6	D7
	Highest						
S	$1^{(3,6)*}$	$1^{(2,3,4,6)}$	$1^{(3,6)}$	$1^{(2,3,6)}$	$1^{(3,4,6,7)}$	1	$1^{(2,3,6)}$
S	$5^{(3,6)}$	$5^{(3,6)}$	$5^{(3)}$	$5^{(3)}$	4	5	$5^{(2,3,6)}$
S	$7^{(3)}$	$7^{(3)}$	$7^{(3)}$	$4^{(2,3,6)}$	5	7	$7^{(3)}$
S	$4^{(3)}$	2.0	$4^{(3)}$	$7^{(3)}$	7	2	$4^{(3)}$
S	2	4	2	6	2	4	6
S	6	6	6	2	6	6	2
S	3	3	3	3	3	3	3
	Least						

* $x^{(y)}$ means that there are significant differences between two success factors on the same delay factor, x success factor is more influential than y success factor in avoiding the same delay factor

S1: Organization planning efforts S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of a control system	D1: Owner’s cash problems during construction D2: Delays in contractor’s progress payments by the owner D3: Slowness in the owner's decision making process D4: Contractor’s financial problems during construction D5: Design errors made by the designer D6: Excessive bureaucracy in the owner’s operation D7: Changes in types or specifications of construction material

SUCCESS FACTORS EFFECT

Results of each of the seven individual 2 (Group) x 7 (Success Factor) two-way ANOVA tests demonstrated a significant effect for Success Factor [range of results: $F(6, 252) = 11.38$, $p<.001$ to $F(6, 156) = 3.12$, $p<0.006$), $\alpha = .05$]

That is, for each of the seven delay factors, respondents identified differences in the influence of the seven critical success factors on each critical delay factor, except excessive bureaucracy in owner's operation (D6); there was no significance between the success factors to avoid this factor. Post-hoc results were included in the Table 5.14 as superscript on the success factors. Separate detailed Tables of post-hoc results can be found in Appendix E

GROUP MAIN EFFECT

The examination of the main effect for group in Table 5.14 reveals that only one analysis exhibited significance. That is, for excessive bureaucracy in owner's operation (D6) $F(1, 26) = 11.71$, $p<0.002$, contractors evaluated the combined influence of success factors as more influential in prevention of (D6) than the owners did; details are found in Table 5.15.

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Table 5-14 Group Main Effect on (D6)

(I) GROUP	(J) GROUP	Mean (I-J)	Sig.(p)
Contractor	Owner	3.87 - 2.95 = 0.920	0.002

Table 5-15 Group Main Effect on (D6)

	Owner n=9		Contractor n=19		Marginal mean (owner+ contractor)/2
Success factors	Mean	St.D.	Mean	St.D.	
S1	3.11	0.93	4.32	0.67	3.72
S2	3.00	1.12	4.05	0.91	3.53
S3	2.78	1.20	3.00	1.33	2.89
S4	2.56	1.01	4.00	1.33	3.28
S5	3.00	1.12	4.42	1.17	3.71
S6	2.89	1.17	3.26	0.87	3.08
S7	3.33	1.12	4.05	1.18	3.69
Average combined success factors =(S1+S2+…+S7)/7	2.95		3.87		

GROUP BY SUCCESS FACTORS (INTERACTION)

There was a significant Group by Success Factor interaction F (6,210) = 2.17, p<0.047 in the case of changes in type or specification of construction material (D7) (see Table 5.16). An examination of Post-hoc comparisons suggests that the relative ranking of influence for each of the seven success factors in preventing changes in type or specification of construction material (D7) was viewed differently by owners and contractors. Specifically, contractors saw the use of control systems (S7) and safety precautions and applied procedures (S6) as less influential than owners did, and clarity of the project scope and work definition (S4) as more influential than owners did.

Table 5-16 Interaction in (D7)

Owners				Contractors			
SF	Mean	Sorting	Ranking	Ranking	Sorting	Mean	SF
1	3.76	3.76	1	1	4.30	4.30	1
2	2.94	3.64	7	5	4.30	3.60	2
3	2.70	3.58	5	4	3.90	2.55	3
4	3.41	3.52	6	7	3.70	3.90	4
5	3.58	3.41	4	2	3.60	4.30	5
6	3.52	2.94	2	6	3.20	3.20	6
7	3.64	2.70	3	3	2.55	3.70	7
Data reading direction →				← Data reading direction			
SF: Success factors Sort: Descending from greatest to least Ranking: Exact hierarchy of importance							

CONCLUSION

The combined owners and contractors analysis highlighted two points that were not clear in the one-way ANOVA results of owners or contractors individually. When examined separately, neither owners nor contractors believed that there was a significant relationship between critical success factors in avoiding design errors made by the designer (D5). However, when these groups were combined a significant correlation of success factors was found for delay (D5), where (S1) became more influential than (S3, S4, S6, and S7). Secondly, in the one-way ANOVA, the contractors' view of excessive bureaucracy in the owner's operation (D6) exhibited a significant relationship for success factors (S1 and S5), which were both more influential in avoiding (D6), yet disappeared in the combined analysis. For the same delay (D6), owners rated

(S7) as most influential in avoiding it, and contractors rated the most influential success factor as (S5). In the combined group (owners and contractors) the most influential success factors at avoiding (D6) was (S1), however separately neither of them rated (S1) as most influential. Also, there was a group main effect for excessive bureaucracy in the owner's operation (D6), where contractors evaluated the combined influence of success factors as more influential in prevention of (D6) than owners did, which is confirmed by the results of the t test illustrated in Table 5.6, where contractors evaluated (S1, S2, S4, and S5) higher than owners did.

Lastly, this test gives more refined view of how the groups (owners and contractors) differed in their evaluation of success factors' influence. The relative ranking of influence for each of the seven success factors in preventing changes in type or specification of construction material (D7) was evaluated differently by owners and contractors; the fact that there were few interactions provides statistical evidence that owners and contractors rank the influence of success factors in preventing delay in a very similar way.

5.3.4.2 Owners, Contractors and Engineers

By examining these three groups together as a combined group examines how they collectively evaluate the seven critical success factors' relative influence on each separate delay factor. The summary results are shown in Figure 5.9 below:

	D1	D2	D3	D4	D5	D6	D7
Success Factors	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Group main effect	No	No	Yes	No	No	Yes	Yes
Interaction	No	No	No	Yes	No	No	No

Figure 5-9 Two Way ANOVA Summary for Owners, Contractors, Engineers

RESULTS DESCRIPTION

An examination of Table 5.18, which is sorted by success factors' influence mean, shows that organization planning efforts (S1) was rated as the most influential success factor on all delay factors with the exception of slowness in owner's decision making process (D3), and excessive bureaucracy in owner's operation (D6). The combined group rated project manger capabilities and experience (S5) as most influential for the latter two delay factors. The results (S1) and (S5) alternate for the first most two influential factors, while project manager's goal commitment (S2), clarity of the project scope and work definition (S4), and use of a control system (S7) vary in the middle range. However, the groups are largely in agreement in rating safety precautions and applied procedures (S6), and project team's motivation and goal orientation (S3) as the least influential success factors. Further details can be found in Appendix F.

SUCCESS FACTORS EFFECT

Results for each of the seven individual 3 (Group) x 7 (Success Factor) two-way Analysis of Variance (ANOVA) tests demonstrated a significant main effect for Success Factors [range of results: $F(12,474) = 18.56$, $p<0.001$ to $F(6,366) = 6.32$, $p<0.001$]. That is, for each of the seven delay factors, respondents identified differences in the influence of the seven success factors. As seen in Table 5.18, all of the delay factors had multiple success factors that had significant differences with other success factors. For example organization planning efforts

Table 5-17 Two Way ANOVA Summary Results for Owners, Contractors, and Engineers

	D1	D2	D3	D4	D5	D6	D7
	Highest						
S	$1^{(2,3,4,6,7)*}$	$1^{(2,3,4,6)}$	$5^{(3,6)}$	$1^{(2,3,6)}$	$1^{(2,3,6,7)}$	$5^{(3,6)}$	$1^{(2,3,6)}$
S	$5^{(3,6)}$	$5^{(3,6)}$	$1^{(3,6)}$	$5^{(3,6)}$	$4^{(3)}$	$1^{(3,6)}$	$5^{(2,3,6)}$
S	$7^{(3,6)}$	$7^{(3,6)}$	$4^{(3,6)}$	$7^{(3,6)}$	7	$7^{(6)}$	$4^{(2,3)}$
S	$4^{(3)}$	$2^{(3)}$	$7^{(3)}$	$4^{(3,6)}$	$5^{(3)}$	$2^{(3)}$	$7^{(3)}$
S	$2^{(3)}$	$4^{(3)}$	$2^{(3)}$	2	2	4	$6^{(3)}$
S	6	6	6	6	6	6	$2^{(3)}$
S	3	3	3	3	3	3	3
	Least						

* $x^{(y)}$ means that there are significant differences between two success factors on the same delay factor, x success factor is more influential than y success factor in avoiding the same delay factor

S1: Organization planning efforts S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of a control system	D1: Owner's cash problems during construction D2: Delays in contractor's progress payments by the owner D3: Slowness in the owner's decision making process D4: Contractor's financial problems during construction D5: Design errors made by the designer D6: Excessive bureaucracy in the owner's operation D7: Changes in types or specifications of construction material

(S1) in owner's cash problems (D1) had more influence than all the other success factors except project manager's capabilities and experience (S5), which was ranked number two. This also occurs in (D1, D2, D4, D5, and D7); organization planning efforts (S1) is repeatedly more influential than (S2, S3, and S6). (S1 and S5) show two consistent patterns. First, they are nearly always the two most influential success factors in preventing critical delays. Second, they are always significantly higher in mean value when compared to (S3 and S6) across all delay factors. Detailed Tables and figures can be found in Appendix F.

GROUP MAIN EFFECT

Examination of the group main effect summary in Table 5.19 shows that three of the analyses demonstrated significant effects, which are:

- Slowness in owner's decision making process (D3); $F(2, 64) = 4.11$, $p<0.018$. Engineers found the combined influence of success factors to be more influential in preventing slowness of owner's decision making process than owners did.
- Excessive bureaucracy in owner's operation (D6); $F(2, 61) = 3.95$, $p<0.020$. Contractors held a stronger belief that the combined influence of success factors is more influential in preventing this critical delay.
- Changes in type or specification of construction material (D7) $F(2, 70) = 5.20$, $p<0.009$ Engineers exemplified a stronger belief than owners that the combined influence of success factors is more influential.

Table 5-18 Group Main Effect on (D3), (D6) and (D7)

	(I) GROUP	(J) GROUP	Mean (I-J)	Sig.(p)
D3	Engineers	Owners	3.99 - 3.27 = 0.721	0.018
D6	Contractors	Owners	3.87 - 2.95 = 0.920	0.020
D7	Engineers	Owners	4.083 - 3.37= 0.706	0.009

INTERACTION

In the case of contractor's financial problems during construction (D4) there was a significant Group by Success Factor interaction F (12, 408) = 1.92, $p<0.03$. An examination of Post-hoc comparisons suggests that the relative ranking of influence for each of the seven success factors in preventing delay related to contractor's financial problems during construction (D4) was equal between owners and contractors, but different for engineers. Specifically, engineers saw use of control systems (S7) and project manager's goal commitment (S2) as of higher influence than owners and engineers did. In addition the engineers rated safety precautions and applied procedures (S6) as less influential than the owners and contractors did.

Table 5-19 Interaction in (D4)

Owners				Contractors				Engineers			
SF	Mean	Sort	Ranking	SF	Mean	Sort	Ranking	SF	Mean	Sort	Ranking
1	4.278	4.278	1	1	4.250	4.25	1	1	4.135	4.135	1
2	3.222	3.833	5	2	3.062	4.125	5	2	3.676	4.000	7
3	3.000	3.722	4	3	2.625	3.813	4	3	3.108	3.676	2
4	3.722	3.5	7	4	3.813	3.688	7	4	3.622	3.622	4
5	3.833	3.278	6	5	4.125	3.188	6	5	3.297	3.297	5
6	3.278	3.222	2	6	3.188	3.062	2	6	2.838	3.108	3
7	3.500	3	3	7	3.688	2.625	3	7	4.000	2.838	6

SF: Success factors
Sort: Descending from greatest to least
Ranking: Exact hierarchy of importance

CONCLUSION

A two-way ANOVA for the three groups (owners, contractors and engineers) revealed that there was agreement between all three groups combined that safety precautions and applied procedures (S6) and project team's motivation and goal orientation (S3) were the least influential success factors for all critical delay factors.

Engineers had a unique perspective regarding contractor's financial problems during construction (D4). In their general experience, they thought use of a control system (S7) and project manager's goal commitment (S2) were more influential in avoiding (D4) than the owners and contractors did on their specific projects. (S5) was thought to be considerably less of a factor. Theoretically, the project manager's goal commitment (S2) and (S7) should improve timely payments to the contractor and avoid contractors' financial problems. However, in reality, they may not be as important as the capabilities and experience of the project manager (S5).

Success factors (S2, S4, S6, and S3) as a group consistently rank lowest (in more than 50% of the cases) in avoiding delay. In three cases, (S4) ranks in the top three, where clarity of the project scope and work definition have a clear influence: (D3), where a lack of clarity could slow decision making by the owners; (D5), where it could lead to incorrect design decisions; and (D7), where a lack of clarity in project scope and work definition could lead to changes in construction materials. It is somewhat surprising that (S3) ranks constantly last throughout. The motivation and cooperation of the project team should play a role in avoiding delay. (S2), project manager's goal commitment, which is a similar idea to (S3) but on an individual basis, consistently ranks above (S3). This is also reflected in the engineers' significant correlation results. (S2) positively correlated with (D1, D3, and D4) while there was no any significant correlation between S3 and any of the delay factors.

Engineers evaluated the combined effect of success factors on their ability to avoid slowness in the owner's decision making process (D3) higher than the owners did. This agrees with the contractors-owners t-test (Table 5.6) where contractors also disagreed with owners on the effectiveness of the success factors on (D3).

Likewise, the contractors and owners differ in the importance of success factors in avoiding on the excessive bureaucracy in the owner's operation (D6). Contractors are more concerned about this delay factor. The reasoning may be that they experience the owners' bureaucracy during the construction process.

Engineers, in their general experience, thought that the success factors as a group would have more influence on (D7) than the owners did, based upon their specific project experience. Whether this difference occurred because, in general, the success factors do have a greater influence than the owners thought they did in the specific projects or whether the engineers believe that they were a greater influence than they do is impossible to determine from this test.

5.3.4.3 Owners and Contractors Averaged and Engineers

The respondents' perceptions in the specific survey (owners and contractors) have been averaged for comparison with those in the general survey (engineers). Since owners and contractors share similar results, their means have been averaged and compared with the engineers' means. Conceptually, this is the optimal method of comparison, since owners and contractors evaluated the same project factors. Statistically, the two groups evaluated the influence of critical success on the critical delay factors similarly in previous tests, with the exception of one interaction, which was for changes in type or specification of construction material (D7).

As in the previous groups, this test also examines the same effects, namely, success factors, group, and group by success factors. Summary results are provided in Figure 5.10 and detailed Tables and Figures can be found in Appendix I.

	D1	D2	D3	D4	D5	D6	D7
Success factors	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Interaction	No	No	No	Yes	No	No	No
Group	No	No	No	No	No	No	Yes

Figure 5-10 Two Way ANOVA Results Summary for Average Group with Engineers

RESULTS DESCRIPTION

An examination of Table 5.20 illustrates that certain critical success factors were seen as more influential in preventing individual critical delay factors. Organization planning efforts (S1) was perceived as most influential in avoiding five of the seven critical delay factors with the exception of slowness in owner's decision making process (D3) and excessive bureaucracy in owner's operation (D6), where the project manger's capability and experience (S5) was rated to be more influential. As in previous cases, project team's motivation and goal orientation (S3), and safety precautions and applied procedures (S6) are the least influential in avoiding delay factors. The other success factors were distributed unevenly in the middle area, beginning with the second most influential and ending with the fifth. For example, clarity of the project scope and work definition (S4) was second most influential at avoiding design errors made by the designer (D5), while in other cases it fell to the fifth position; similar results can be observed for use of a control system (S7), project manager's capabilities and experience (S5), and project manager's goal commitment (S2).

SUCCESS FACTORS EFFECT

Results of each of the seven individual 2 (Group) x 7 (Success Factor) two-way Analysis of Variance (ANOVA) tests demonstrated a significant main effect for all success factors [range of results: $F(6,390) = 18.98$, $p<.001$ to $F(6,306) = 8.460$, $p<0.001$]. That is, for each of the seven delay factors, respondents identified significant differences in the influence of the seven success factors. In terms of rank, the top rank remains the same as in the previous test of owners, contractors, and engineers: in a mix of (S1 and S5).

However, there are some changes in rank two: in D2 and D4, S7 takes the place of S5. The lowest two ranks remain predominately (S6 and S3). Compared to owners, contractors, and engineers, the top three remain the same – mostly (S1, S5, and S7); changes occur in (D4 and D6).

Table 5-20 Two Way ANOVA Summary Results for Average Group with Engineers

	D1	D2	D3	D4	D5	D6	D7
	Highest						
S	$1^{(2,3,4,6,7)*}$	$1^{(2,3,4,6)}$	$5^{(3,6)}$	$1^{(2,3,6)}$	$1^{(2,3,5,6,7)}$	$5^{(3,6)}$	$1^{(2,3,6)}$
S	$5^{(6)}$	$7^{(3,6)}$	$1^{(3,6)}$	$7^{(3,6)}$	$4^{(3)}$	$1^{(3,6)}$	$5^{(2,3,6)}$
S	$7^{(3,6)}$	$5^{(3,4,6)}$	$4^{(3,6)}$	$4^{(3,6)}$	$7^{(6)}$	$2^{(3,6)}$	$4^{(2,3)}$
S	$2^{(3)}$	$2^{(3)}$	$2^{(3,6)}$	$5^{(3,6)}$	5	$7^{(3,6)}$	$7^{(3)}$
S	$4^{(3)}$	$4^{(3)}$	$7^{(6)}$	2	2	$4^{(6)}$	$6^{(3)}$
S	6	6	3	6	6	6	$2^{(3)}$
S	3	3	6	3	3	3	3
	Least						

* $x^{(y)}$ means that there are significant differences between two success factors on the same delay factor, x success factor is more influential than y success factor in avoiding the same delay factor

S1: Organization planning efforts	D1: Owner’s cash problems during construction
S2: Project manager's goal commitment	D2: Delays in contractor’s progress payments by the owner
S3: Project team's motivation and goal orientation	D3: Slowness in the owner's decision making process
S4: Clarity of the project scope and work definition	D4: Contractor’s financial problems during construction
S5: Project manager's capabilities and experience	D5: Design errors made by the designer
S6: Safety precautions and applied procedures	D6: Excessive bureaucracy in the owner’s operation
S7: Use of a control system	D7: Changes in types or specifications of construction material

GROUP MAIN EFFECT

Examination of the group main effect (Table 5.21) revealed only one analysis of significance. For changes in types or specification of construction material (D7), $F (1, 61) = 11.28$, $p<0.001$, engineers thought that the combined influence of success factors in avoiding delays related to (D7) was greater than the average group. This finding reflects the previous owners/contractor/engineer group analysis, which showed the same result. By averaging the means of the owners and the contractors, the group effect on D3 in the previous O/C/E test did not show up in this test.

Table 5-21 Group Main Effect on (D7)

(I) GROUP	(J) GROUP	I - J	Mean (I-J)	Sig.(p)
Engineers	Average	4.08 - 3.42	0.657(*)	0.001

INTERACTION

In the case of contractor's financial problems during construction (D4) there was a significant Group by Success Factor interaction $F (6,336) = 2.69$, $p<0.014$. An examination of Post-hoc comparisons suggests that the relative ranking of influence for each of the seven success factors in preventing contractor's financial problems during construction (D4) was viewed differently by specific project respondents and general experience respondents. Specifically, general experience respondents saw use of a control system (S7) and project manager's goal commitment (S2) as highly influential, and project manager's capabilities and experience (S5) and safety precautions and applied procedures (S6) as less influential (See Table 5.22).These results mirror the previous owners, contractors, and engineers' two-way ANOVA results. Additional Tables and Figures can be found in Appendix G.

Table 5-22 Interaction on (D4)

Specific				Engineers			
SF	Mean	Sorting	Ranking	Ranking	Sorting	Mean	SF
1	4.333	4.333	1	1	4.135	4.135	1
2	3.238	4	5	7	4	3.676	2
3	2.905	3.81	4	2	3.676	3.108	3
4	3.810	3.595	7	4	3.622	3.622	4
5	4.000	3.31	6	5	3.297	3.297	5
6	3.310	3.238	2	3	3.108	2.838	6
7	3.595	2.905	3	6	2.838	4.000	7
Data direction →					← Data direction		
Where SF: Success factors, Sorting: From maximum on the top to the minimum means Ranking: Exact hierarchy of importance							

CONCLUSION

In the last group tested, which was an average of specific project respondents, owners, and contractors collectively with general experience respondents (engineers), only one group by success factor (significant interaction) existed among all seven tested delay factors, which was for contractor's financial problems during construction (D4), where each group identified different success factors that help to avoid this delay factor. Specifically, general experience respondents (engineers) saw use of a control system (S7) and boosting of project manager's goal commitment (S2) as highly influential, and project manager's capabilities and experience (S5) and safety precautions and applied procedures (S6) as less influential than the specific project respondents thought. On the other hand, the specific project respondent average group thought project manager's capabilities and experience (S5), along with clarity of the project scope and work definition (S4) were the most influential at avoiding D4, second to organization planning efforts, which ranked first for both groups at avoiding said delay. This agreement strongly indicates that both groups evaluated success factors with similar experiences in mind.

In terms of overall ranking of the success factors influence, there was general agreement between both groups that organization planning efforts (S1) and project manager's capabilities and experience (S5) were most influential. Conversely, there was general agreement that safety precautions and applied procedures (S6) and project team's motivation and goal orientation (S3) were the least influential critical success factors in avoiding or preventing the selected critical delay factors. Other factors, such as use of a control system (S7), project manager's goal commitment (S2), and clarity of the project scope and work definition (S4) varied in the middle range. Analysis detailed tables and figures can be found in Appendix G.

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6.0 RESEARCH CONCLUSION

As mentioned in chapters one and two, the motivation of this study was to examine the relationships between critical success and delay factors identified from the literature. Seven critical success and delay factors were chosen for further analysis and more precisely to determine which of the critical success factors had the most influence in avoiding critical delay factors, filling a gap in research and providing construction management with information that could lead to more successful project planning.

6.1 TESTS SUMMARY

6.1.1 Critical Success and Delay Factors Correlation

Critical success and delay factors evaluated by owners, contractors, and engineers have been examined using Pearson's correlation coefficient to measure the strength and direction of relationship between these factors either for the same project in the case of owners and contractors, or in general for the case of engineers. In the owners' case there was one significant positive correlation between Safety precautions and applied procedures (S6) and efficiency of owner's operation (bureaucracy) (D6). Owners' concerns about accidents or problems due lack of adherence to safety procedures may be one reason they have a tendency to highly rate safety procedures' effects on the overall construction process. As shown in the final results evaluation, owners almost always rank (S6) higher than contractors and engineers as can be seen in the one way ANOVA results in Tables 5.9, 5.11, and 5.12.

For contractors there were three significant negative correlations between success factors project manager's goal commitment (S2), project team's motivation and goal orientation (S3), and clarity of project scope and work definition (S4) and delays related to changes in types or specification of construction material (D7). Contractors believed that increasing the goal commitment of the project manager, increasing the motivation and goal orientation of the project team, and clarifying the project scope and definition would reduce delays related to changes in types or specification of construction materials. These correlations can be understood in the context of practice. However in one way ANOVA contractors results (Table 5.11) clarity of project scope and work definition (S4) fell in the third importance success factors in avoiding (D7), Project manager's goal commitment (S2), and lastly the seventh is the project team's motivation and goal orientation (S3).

Engineers expressed that organization planning efforts (S1) and the control system used for a project (S7) correlated with all seven critical delay factors, while there was not one significant correlation between motivation and goal orientation of the project team (S3) with any of the critical delay factors. This has been confirmed by one way ANOVA results that showed highly importance for (S1, S7) and less important for (S3).

6.1.2 t-tests of Owners and Contractors' Responses

This test compared owners' and contractors' perceptions of critical success factors, critical delay factors, and influence of critical success factors on each of the seven critical delay factors by comparing their means. In general, there were few significant differences between owners and contractors' perceptions. Owners and contractors evaluated the critical success, critical delay factors, and influence of the critical success factors in avoiding each delay factor similarly except for excessive bureaucracy in the owner’s operation (D6), where contractors evaluated the four success factors higher than owners did. This has been noticed in two way ANOVA results twice in the owners and contractors combined group and in three group analysis (owners, contractors, and engineers) contractors held a stronger belief that the combined influence of success factors is more influential in preventing this critical delay.

Contractors evaluated delay factors related to owners more critically than owners did. For example, contractors’ responses were significantly different than owners for owner’s cash problems during construction (D1). Contractors thought that this delay factor was more important than owners. Contractors evaluated the project manager's capabilities and experience (S5) as having more importance than the owners did. Likewise, owners rated project team's motivation and goal orientation (S3) more highly than contractors’ did. However, owners ranked (S3) as last in six of seven delay factors in one-way ANOVA, and contractors correlated it with (D7). This trend also continued for slowness in the owner's decision making process (D3) and excessive bureaucracy in the owner’s operation (D6). Other than these instances, there was general agreement between both owners and contractors regarding the overall evaluation of critical success factors, critical delay factors, and the influence of critical success factors on critical delay factors for the same project.

6.1.3 Critical Success Factors Influence on Critical Delay Factors

Concerning the influence of critical success factors upon avoiding or preventing delay factors, it was not initially expected that nearly all tested groups (owners, contractors, and engineers) would be in agreement regarding which critical success factors were most influential in avoiding or preventing critical delay factors. This was true whether the results were examined separately or collectively. The most influential critical success factors were organization planning efforts (S1) and project manager's capabilities and experience (S5). In contrast, safety precautions and applied procedures (S6) and project team's motivation and goal orientation (S3) were the least influential critical success factors in avoiding or preventing delay related to the seven critical delay factors; other success factors varied in the middle range.

For specific project respondents (owners and contractors) there was only one group main effect, which involved contractors' higher evaluation of owner's bureaucracy (D6) when compared to owners. This phenomenon has been witnessed multiple times during data analysis, which was best shown in the t test (Table 5.6), where there were significant differences between contractors' and owners' evaluations of how to avoid this delay factor, group main effect in owners and contractors one two way ANOVA results (Table 5.14) and in three group (owners, contractors, and engineers) two way ANOVA results (Table 5.18). Furthermore, data shows that engineers strongly agree with the contractors' evaluations of excessive owner's bureaucracy (D6); 81.4% of those sampled in the engineers' survey thought that bureaucracy was either a very strong or strong influence on the delay of construction projects in Saudi Arabia.

There was one group by success effect (interaction). Specifically, contractors saw use of control systems (S7) and safety precautions and applied procedures (S6) as less influential than owners did, and clarity of the project scope and work definition (S4) as more influential than the owners did. This leads us to conclude that owners and contractors are largely in agreement with regards to their evaluation of success factors that avoid delay factors.

6.2 STUDY CONCLUSION

The conclusion from the previous comparisons exemplifies that there is a strong agreement between groups (owners, contractors, and engineers). This is clearly noticed in the last group analysis (owners and contractors averaged with engineers) average of specific project respondents and the general experience or engineers group. On the other hand, one could assume that both groups are in agreement because all of them were engineers, or because the factors are by their nature critical, and subsequently perceived as such. However, new hierarchy scheme for the seven critical success factors in avoiding the given critical delay factors have been created based on the importance of critical success factors out come of these research findings. Owners over all have been explained below as example of how this new importance hierarchy derived.

6.2.1 Owners Overall Importance

Method of evaluating the relative importance of the success factors (across all delay factors) for each group was developed:

$$\text{Success factor importance} = \sum_{r=1}^{r=7} (f) \times (r)$$

Where r = rank from 1 to 7 and f = frequency that a specific rank was assigned to a success factor across the 7 delay factors.

The first step was to rank the means for the seven success factors for each delay factor. For example the success factor that had the lowest mean (rating of influence on the delay factor) would be assigned the rank of 1; the success factor that had the highest mean (rating of influence on the delay factor) would be assigned the rank of 7. Next, the importance index was computed as the sum of the products of the frequency (across the 7 delay factors) each success factor received a given rank times the numeric value of the rank. Since there are 7 delay factors the frequencies must sum to 7. For example, consider Success factor one for owners table 6.1. success factor one received the rank of 7 for all delay factors except for delay factor six where it received the rank of 6. The data for success factor one may be summarized as shown in table 6.2.

Table 6-1 One Way ANOVA Summary Results for Owners

	D1	D2	D3	D4	D5	D6	D7	Overall
Highest								
S	1	1	1	1	1	7	1	S1
S	5	7	5	5	7	1	7	S7
S	7	5	7	4	5	2	5	S5
S	4	2	4	7	6	5	6	S4
S	6	4	6	6	2	6	4	S6
S	2	6	2	2	4	3	2	S2
S	3	3	3	3	3	4	3	S3
Least								

S1: Organization planning efforts S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of a control system	D1: Owner’s cash problems during construction D2: Delays in contractor’s progress payments by the owner D3: Slowness in the owner's decision making process D4: Contractor’s financial problems during construction D5: Design errors made by the designer D6: Excessive bureaucracy in the owner’s operation D7: Changes in types or specifications of construction material

Table 6-2 Success factor one in owners case

								Total
Rank	1	2	3	4	5	6	7	
Freq	0	0	0	0	0	1	6	
Product	0	0	0	0	0	6	42	48

6.2.2 Groups Overall Perceived Success Factors Importance

The overall importance for each tested group and the study overall success factors conclusion listed in Figure 6.1.

O	C	E	O + C	O + C + E	(O+C)average +E	Overall
S1	S1	S21	S1	S1	S1	S1
S7	S5	S7	S5	S5	S5	S5
S5	S4	S5	S7	S7	S7	S7
S4	S7	S2	S4	S4	S2	S4
S6	S2	S4	S2	S2	S4	S2
S2	S6	S6	S6	S6	S6	S6
S3	S3	S3	S3	S3	S3	S3

Where
O : Owners, C: Contractor, E: Engineers (weighted one way ANOVA)
O+C: Owners and contractors – combined (weighted two way ANOVA)
O+C+E: owners, contractors and, and engineers – combined (weighted two way ANOVA)
(O+C) average +E: average of owners + contractors with Engineers combined (weighted two way ANOVA)

Figure 6-1 Groups Final Success Factors Evaluation

We see that the priority of success factors reflected in this study not the same as in the priorities in previous literature because success was defined more broadly than just delay. For example, project team motivation and goal orientation (S3) was the third most important success factor in the literatures' findings. However in this study's outcomes it was the last and least important, while organization planning efforts kept its rank as the most important success factor. This alternative ranking of success factors could be for a number of reasons. First, the study allowed for only seven success factors, which may have affected their priority. Secondly, the target project was public, and was evaluated by different project participants. In opposite, factors in the literature (Ashley et al.1987) were extracted through the examination of eight companies, each contributing one average and one outstanding project, totaling 16 projects, 82% of which were private. Given the study circumstances and conditions, the hierarchy derived from this study is consistently supported by the results from all three groups,

6.3 LIMITATIONS OF THE RESEARCH

Some limitations were discovered during questionnaire production and the data collection and analysis phase, which are listed below:

- Data collection took place during the summer, a season in which most of the targeted engineers were on vacation. This had a negative impact on the response rate.
- Specific project responses were limited because the questionnaires requested detailed information about projects that in some cases could only be obtained by reexamining the project file.

- Translating survey questionnaires from English to Arabic was intended to increase the response rate and make it easier for some participants. However the process of translating feedback data back into English may have created some gaps in meaning, and subsequently effected results.
- Respondents were encouraged to provide any new, unique, or unlisted success or delay factors. Unfortunately, few responses were given.
- Success factors affected a broad set of project concerns, and were broader than the set of delay factors. Other success factors not included in the study may have a high contribution to the reduction of the top seven delay factors.
- The targeted project cases differed according to project type, designer type, kind of contract, and contractor classification.
- After final evaluation of this studies success factors, we found that their priority differed from the primary resource (Ashley et al.1987). This could be because the present research was more concerned with a specified list of delay factors.

6.4 CONTRIBUTION OF THE RESEARCH

It is hoped that the present study will contribute to the field by integrating knowledge of not only critical success factors, but what is known about critical delay factors. By learning which critical success factors are perceived as most influential in avoiding or preventing critical delay factors, this study can lead to better performance for construction industries. Although the case study presented here was based in Saudi Arabia it is hoped that these results would be broadly applicable. A unique strength of the present study, aside from being the first to investigate the relationship between critical success and delay factors, is that it collected identical data from both owners and contractors who on the same specific project. Separate survey data was also collected from engineers, who responded based on their general experience. Previous studies approached the topic of delay or success factors either from the perspective of specific projects or from a general perspective, but never from both perspectives. Finally this study can be used as solid foundation for future studies that examine critical success and delay factor relationships.

6.5 RECOMMENDATIONS FOR FUTURE STUDIES

Future studies examining the effects of critical success factors to avoid or prevent delay factors in the construction industry may want to consider some of the following suggestions:

- Critical success factors found most influential in this study could be utilized in a future work that examines different situations and environments. For example one could look specifically at industrial facilities, or private sector projects.
- Applying the same study criteria to other countries could be examined.
- One could use some of this study's ideas but focus specifically on projects that experienced significant delays.
- This study could be extended by adding the opinions of consultants, who might provide the researcher with more neutral data. However, due to the nature of public projects in Saudi Arabia, where consultants are part of the owner's engineering team, it was not possible to implement this.

APPENDIX A

t TEST SUMMARY RESULTS

The Independent Samples t test was used to compare the population means based on sample statistics from two independent populations. In this study a t test was used to compare owners' and contractors' perceptions of the influence of individual success factors on individual delay factors for specific projects. Table A - 1 (owners and contractors -t test - Success Factors), Table A - 2 (owners and contractors - t test - Delay Factors) and Table A - 3 (Owners and Contractors t test- influence of critical success factors on avoiding critical delay factors) showed the studied cases have been conducted using this statistical method.

APPENDIX A1

OWNERS AND CONTRACTORS

Table A - 1 Owners and Contractors –t test – Success Factors

	GROUP	N	Mean	Std. D.	t	Sig.(p)
S1	Owners	31	3.9677	0.83602	-0.82	0.418
	Contractors	31	4.1290	0.71842		
S2	Owners	31	3.8065	0.74919	-0.78	0.439
	Contractors	31	3.9677	0.87498		
S3	Owners	31	3.3226	0.94471	2.08	0.042
	Contractors	31	2.7419	1.23741		
S4	Owners	31	3.8387	0.86011	-0.40	0.690
	Contractors	31	3.9355	1.03071		
S5	Owners	31	3.8065	0.87252	-2.72	0.009
	Contractors	31	4.3548	0.70938		
S6	Owners	31	3.4839	0.76902	0.29	0.771
	Contractors	31	3.4194	0.95827		
S7	Owners	30	3.8000	0.88668	0.53	0.596
	Contractors	31	3.6774	0.90874		

Where:

- S1: Organization planning efforts
- S2: Project manager's goal commitment
- S3: Project team's motivation and goal orientation
- S4: Clarity of the project scope and work definition
- S5: Project manager's capabilities and experience
- S6: Safety precautions and applied procedures
- S7: Use of a control system

Table A 2 Owners and Contractors – t test – Delay Factors

	GROUP	N	Mean	Std. D.	t	Sig.(p)
D1	Owners	31	3.7419	0.92979	2.447	0.017
	Contractors	31	3.0968	1.13592		
D2	Owners	31	3.8387	0.77875	0.881	0.382
	Contractors	31	3.5806	1.43235		
D 3	Owners	31	3.5484	1.31247	-0.469	0.641
	Contractors	31	3.7097	1.39508		
D 4	Owners	31	3.9677	0.98265	1.755	0.084
	Contractors	31	3.4839	1.17958		
D 5	Owners	30	3.1667	1.11675	-0.213	0.832
	Contractors	31	3.2258	1.05545		
D 6	Owners	31	3.2903	1.10132	-1.380	0.173
	Contractors	31	3.6774	1.10716		
D 7	Owners	29	3.5172	0.98636	-1.321	0.192
	Contractors	31	3.8387	0.89803		

Where:

- D1: Owner's cash availability
- D2: Timeliness of owner's payments to contractor
- D3: Timeliness of decision making by owner
- D4: Contractor's funding availability
- D5: Design errors by designer
- D6: Efficiency of project owner’s operation (bureaucracy)
- D7: Changes in types or specifications of construction material

Table A - 3 Owners and Contractors t test- CSF's on CDF's

Delay 1							Delay 2						
GROUP		N	Mean	St.D.	t	Sig.	GROUP		N	Mean	St.D.	t	Sig.
S1D1	O	9	4.44	0.53	-0.20	0.84	S1D2	O	17	3.94	0.89	-2.00	0.051
	C	12	4.50	0.67				C	27	4.44	0.75		
S2D1	O	10	3.80	1.14	1.11	0.28	S2D2	O	17	3.17	1..28	-0.69	0.491
	C	12	3.17	1.47				C	27	3.44	1..22		
S3D1	O	10	2.70	1.34	0.20	0.85	S3D2	O	17	2.58	1..27	-0.55	0.585
	C	12	2.58	1.44				C	27	2.81	1..35		
S4D1	O	10	3.50	1.26	0.134	0.90	S4D2	O	17	2.94	1.24	-1.66	0.104
	C	12	3.42	1.51				C	27	3.62	1.39		
S5D1	O	10	4.00	1.25	0.30	0.78	S5D2	O	17	3.23	1.14	-1.77	0.084 .
	C	12	3.83	1.40				C	27	3.92	1.32		
S6D1	O	10	3.50	1.08	1.52	0.15	S6D2	O	17	2.88	1.11	-0.97	0.340
	C	12	2.75	1.22				C	27	3.22	1.15		
S7D1	O	10	3.70	1.06	0.80	0.43	S7D2	O	17	3.29	1..57	-1.27	0.21
	C	12	3.25	1.50				C	27	3.85	1.32		

Where :
CSF: critical success factors
CDF: critical delay factors
O: owners, C: contractors
S1D1: influence of success factor 1 on delay factor 1 and so on for all success factors on each delay factor.

Table A - 3 Continued

Delay 3							Delay 4						
GROUP		N	Mean	St.D.	t	Sig.	GROUP		N	Mean	St.D.	t	Sig.
S1D1	O	10	3.70	1.05	-2.176	0.038	S1D2	O	18	4.20	0.89	0.096	0.924
	C	20	4.35	0.58				C	16	4.25	0.77		
S2D1	O	10	2.90	1.66	-2.243	0.033	S2D2	O	18	3.22	1.06	0.388	0.701
	C	20	4.00	1.02				C	16	3.06	1.34		
S3D1	O	10	2.60	1.07	-.820	0.419	S3D2	O	18	3.00	1.28	0.799	0.430
	C	20	3.00	1.33				C	16	2.62	1.45		
S4D1	O	10	3.30	1.05	-2.034	0.051	S4D2	O	18	3.72	1.27	-0.199	0.844
	C	20	4.00	0.79				C	16	3.81	1.37		
S5D1	O	10	3.60	1.07	-1.458	0.156	S5D2	O	18	3.83	1.20	-0.677	0.503
	C	20	4.20	1.05				C	16	4.12	1.31		
S6D1	O	10	3.20	0.78	0.145	0.886	S6D2	O	18	3.27	1.12	0.248	0.806
	C	20	3.15	0.93				C	16	3.18	0.98		
S7D1	O	10	3.60	0.84	-0.386	0.702	S7D2	O	18	3.50	1.15	-0.466	0.645
	C	20	3.75	1.06				C	16	3.68	1.19		

Where :
CSF: critical success factors
CDF: critical delay factors
O: owners, C: contractors
S1D1: influence of success factor 1 on delay factor 1 and so on for all success factors on each delay factor.

Table A-3 Continued

Delay 5							Delay 6						
GROUP		N	Mean	St.D.	t	Sig.	GROUP		N	Mean	St.D.	t	Sig.
S1D1	O	12	3.83	1.02	-1.79	0.086	S1D2	O	9	3.11	0.92	-3.92	0.001
	C	14	4.42	0.64				C	19	4.31	0.67		
S2D1	O	12	2.91	1.08	-1.05	0.301	S2D2	O	9	3.00	1.11	-2.66	0.013
	C	14	3.42	1.34				C	19	4.05	0.91		
S3D1	O	12	2.50	1.16	-.262	0.796	S3D2	O	9	2.77	1.20	-0.42	0.675
	C	14	2.64	1.54				C	19	3.00	1.33		
S4D1	O	12	3.16	1.19	-1.84	0.078	S4D2	O	9	2.55	1.01	-2.87	0.008
	C	14	4.00	1.10				C	19	4.00	1.33		
S5D1	O	12	3.08	1.16	-1.31	0.201	S5D2	O	9	3.00	1.11	-3.04	0.005
	C	14	3.71	1.26				C	19	4.42	1.16		
S6D1	O	12	3.25	0.86	0.094	0.926	S6D2	O	9	2.88	1.16	-0.95	0.350
	C	14	3.21	1.05				C	19	3.26	.087		
S7D1	O	11	3.27	1.10	-0.53	0.599	S7D2	O	9	3.33	1.11	-1.53	0.137
	C	14	3.50	1.01				C	19	4.05	1.17		

Where :
CSF: critical success factors
CDF: critical delay factors
O: Owners, C: Contractors
S1D1: influence of success factor 1 on delay factor 1 and so on for all success factors on each delay factor.

Table A-3 Continued

Delay 7						
GROUP		N	Mean	St.D.	t	Sig.
S1D1	O	17	3.76	1.14	-1.66	0.105
	C	20	4.30	0.80		
S2D1	O	17	2.94	0.96	-1.82	0.076
	C	20	3.60	1.18		
S3D1	O	17	2.70	0.91	0.372	0.712
	C	20	2.55	1.50		
S4D1	O	17	3.41	1.17	-1.321	0.195
	C	20	3.90	1.07		
S5D1	O	17	3.58	1.27	-1.799	0.081
	C	20	4.30	1.12		
S6D1	O	17	3.52	0.94	0.876	0.387
	C	20	3.20	1.28		
S7D1	O	17	3.64	1.16	-0.122	0.903
	C	20	3.70	1.41		

Where :
CSF: critical success factors
CDF: critical delay factors
O: owners, C: contractors
S1D1: influence of success factor 1 on delay factor 1 and so on for all success factors on each delay factor.

APPENDIX B

OWNERS ONE WAY ANOVA – SUMMARY RESULTS

Table B - 1 One way ANOVA – Owners

	D1	D2	D3	D4	D5	D6	D7
S1	4.4444	3.9412	3.7000	4.2778	3.7273	3.1111	3.7647
S2	3.6667	3.1765	2.9000	3.2222	3.0000	3.0000	2.9412
S3	2.8889	2.5882	2.6000	3.0000	2.6364	2.7778	2.7059
S4	3.7778	2.9412	3.3000	3.7222	3.0000	2.5556	3.4118
S5	4.3333	3.2353	3.6000	3.8333	3.1818	3.0000	3.5882
S6	3.7778	2.8824	3.2000	3.2778	3.1818	2.8889	3.5294
S7	4.0000	3.2941	3.6000	3.5000	3.2727	3.3333	3.6471
Sorting success factors by mean (from max. at the top to the min.)							
S	4.4444	3.9412	3.7000	4.2778	3.7273	3.3333	3.7647
S	4.3333	3.2941	3.6000	3.8333	3.2727	3.1111	3.6471
S	4.0000	3.2353	3.6000	3.7222	3.1818	3.0000	3.5882
S	3.7778	3.1765	3.3000	3.5000	3.1818	3.0000	3.5294
S	3.7778	2.9412	3.2000	3.2778	3.0000	2.8889	3.4118
S	3.6667	2.8824	2.9000	3.2222	3.0000	2.7778	2.9412
S	2.8889	2.5882	2.6000	3.0000	2.6364	2.5556	2.7059

Table B – 1 Continued

	D1	D2	D3	D4	D5	D6	D7
Sorting success factors by mean (from max. at the top to the min.) according to success factors number							
S	1	1	1	$1^{(3)*}$	1	7	$1^{(2)}$
S	5	7	5	5	7	1	7
S	7	5	7	4	5	2	5
S	4	2	4	7	6	5	6
S	6	4	6	6	2	6	4
S	2	6	2	2	4	3	2
S	3	3	3	3	3	4	3
S1: Organization planning efforts S2: Project manager's goal commitment S3: Project team's motivation and goal orientation S4: Clarity of the project scope and work definition S5: Project manager's capabilities and experience S6: Safety precautions and applied procedures S7: Use of a control system				D1: Owner's cash problems during construction D2: Delays in contractor's progress payments by the owner D3: Slowness in the owner's decision making process D4: Contractor's financial problems during construction D5: Design errors made by the designer D6: Excessive bureaucracy in the owner's operation D7: Changes in types or specifications of construction material			

APPENDIX C

CONTRACTORS - ONE WAY ANOVA – SUMMARY RESULTS

Table C 1 One way ANOVA – Contractors

Delay 1							Delay 2					
	Mean	St. D.	N	Sorting	Rank			Mean	St. D.	N	Sorting	Rank
S1	4.50	0.67	12	4.50	1		S1	4.44	0.75	27	4.44	1
S2	3.16	1.46	12	3.83	5		S2	3.44	1.21	27	3.92	5
S3	2.58	1.44	12	3.41	4		S3	2.81	1.35	27	3.85	7
S4	3.41	1.50	12	3.25	7		S4	3.62	1.39	27	3.62	4
S5	3.83	1.40	12	3.16	2		S5	3.92	1.37	27	3.44	2
S6	2.75	1.21	12	2.75	6		S6	3.22	1.15	27	3.22	6
S7	3.25	1.48	12	2.58	3		S7	3.85	1.32	27	2.81	3
Delay 3							Delay 4					
	Mean	St. D.	N	Sorting	Rank			Mean	St. D.	N	Sorting	Rank
S1	4.35	0.58	20	4.35	1		S1	4.25	0.77	16	4.25	1
S2	4.00	1.02	20	4.20	5		S2	3.06	1.34	16	4.12	5
S3	3.00	1.33	20	4.00	2		S3	2.62	1.45	16	3.81	4
S4	4.00	0.79	20	4.00	4		S4	3.81	1.37	16	3.68	7
S5	4.20	1.05	20	3.70	7		S5	4.12	1.31	16	3.18	6
S6	3.15	0.93	20	3.15	6		S6	3.18	0.90	16	3.06	2
S7	3.75	1.06	20	3.00	3		S7	3.68	1.19	16	2.62	3

Table C 1 Continued

Delay 5					
	Mean	St.D.	N	Sorting	Rank
S1	4.42	0.64	14	4.42	1
S2	3.42	1.34	14	4.00	4
S3	2.64	1.54	14	3.71	5
S4	4.00	1.10	14	3.50	7
S5	3.71	1.26	14	3.42	2
S6	3.21	1.05	14	3.21	6
S7	3.50	1.01	14	2.64	3

Delay 6					
	Mean	St.D.	N	Sorting	Rank
S1	4.31	0.67	19	4.42	5
S2	4.05	0.91	19	4.31	1
S3	3.00	1.33	19	4.05	2
S4	4.00	1.33	19	4.05	7
S5	4.42	1.16	19	4.00	4
S6	3.26	0.87	19	3.26	6
S7	4.05	1.17	19	3.00	3

Delay 7					
	Mean	St.D.	N	Sorting	Rank
S1	4.30	0.80	20	4.30	1
S2	3.60	1.18	20	4.30	5
S3	2.55	1.50	20	3.90	4
S4	3.90	1.07	20	3.70	7
S5	4.30	1.12	20	3.60	2
S6	3.20	1.21	20	3.20	6
S7	3.70	1.41	20	2.55	3

Table C 2 Contractors - Post hoc

Delay 1			
(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	3	1.91	0.016
1	6	1.75	0.028

Delay 2			
(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	2	1.00	0.044
1	3	1.63	0.000
1	6	1.22	0.000
3	4	-0.81	0.021
3	5	-1.11	0.002
3	7	-1.03	0.001
5	6	0.70	0.015
6	7	-0.63	0.003

Delay 3			
(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	3	1.35	0.018
1	6	1.20	0.001
2	3	1.00	0.017
2	4	-1.00	0.002
2	5	-1.20	0.014
5	6	1.05	0.013

Delay 4			
(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	3	1.62	0.020
1	6	1.06	0.038
3	5	-1.50	0.008

Table C 2 Continued

Delay 5					Delay 6			
(I) SF	(J) SF	Mean (I-J)	Sig.(p)		(I) SF	(J) SF	Mean (I-J)	Sig.(p)
No significant (Success factors difference)					1	3	1.31	0.009
					1	6	1.05	0.004
					3	5	-1.42	0.005
					5	6	1.15	0.017
Delay 7								
(I) SF	(J) SF	Mean (I-J)	Sig.(0)					
1	3	1.75	0.010					
1	6	1.10	0.019					
2	3	1.05	0.043					
2	5	-0.70	0.038					
3	4	-1.35	0.004					
3	5	-1.75	0.002					
5	6	1.10	0.007					

APPENDIX D

ENGINEERS - ONE WAY ANOVA – SUMMARY RESULTS

Table D 1 One way ANOVA - Engineers

Delay 1							Delay 2					
	Mean	Std D.	N	Sorting	Rank			Mean	Std D.	N	Sorting	Rank
S1	4.5000	0.84732	40	4.5000	S1		S1	4.1579	1.10347	38	4.1579	S1
S2	3.6500	1.18862	40	4.1000	S7		S2	3.9474	0.89887	38	4.1579	S5
S3	3.1250	1.36227	40	3.9750	S5		S3	3.1316	1.29805	38	4.1316	S7
S4	3.6250	1.29471	40	3.6500	S2		S4	3.5263	1.35041	38	3.9474	S2
S5	3.9750	1.07387	40	3.6250	S4		S5	4.1579	1.17465	38	3.5263	S4
S6	3.2750	1.13199	40	3.2750	S6		S6	3.2105	1.31843	38	3.2105	S6
S7	4.1000	0.92819	40	3.1250	S3		S7	4.1316	1.09473	38	3.1316	S3
Delay 3							Delay 4					
S1	4.2432	0.89460	37	4.5135	S5		S1	4.1351	0.94757	37	4.1351	S1
S2	4.2432	0.79601	37	4.2703	S4		S2	3.6757	1.29216	37	4.0000	S7
S3	3.4865	1.30430	37	4.2432	S1		S3	3.1081	1.44883	37	3.6757	S2
S4	4.2703	1.01786	37	4.2432	S2		S4	3.6216	1.36120	37	3.6216	S4
S5	4.5135	0.65071	37	3.9459	S7		S5	3.2973	1.52507	37	3.2973	S5
S6	3.2432	1.47959	37	3.4865	S3		S6	2.8378	1.42426	37	3.1081	S3
S7	3.9459	1.17724	37	3.2432	S6		S7	4.0000	1.13039	37	2.8378	S6

Table D 1 Continued

Delay 5							Delay 6					
	Mean	Std D.	N	Sorting	Rank			Mean	Std D.	N	Sorting	Rank
S1	4.3333	0.71714	36	4.3333	S1		S1	3.9722	1.29804	36	4.1667	S5
S2	3.0833	1.46141	36	3.7222	S7		S2	3.8056	1.16667	36	3.9722	S1
S3	2.8611	1.49576	36	3.6667	S4		S3	2.9722	1.53969	36	3.8056	S2
S4	3.6667	1.49284	36	3.2222	S5		S4	3.6944	1.36945	36	3.6944	S4
S5	3.2222	1.56955	36	3.0833	S2		S5	4.1667	1.08233	36	3.5556	S7
S6	2.8333	1.40408	36	2.8611	S3		S6	3.0000	1.37321	36	3.0000	S6
S7	3.7222	1.25610	36	2.8333	S6		S7	3.5556	1.34046	36	2.9722	S3
Delay7												
S1	4.3056	0.92023	36	4.3611	S4							
S2	3.8333	1.08233	36	4.3611	S5							
S3	3.5000	1.20712	36	4.3056	S1							
S4	4.3611	0.76168	36	4.1389	S7							
S5	4.3611	0.86694	36	4.0278	S6							
S6	4.0278	1.13354	36	3.8333	S2							
S7	4.1389	1.09942	36	3.5000	S3							

Table D 2 Engineers -Success Factors Effect - Post hoc

Delay 1

(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	2	0.850	0.002
1	3	1.375	0.000
1	4	0.875	0.004
1	6	1.225	0.000
1	7	0.400	0.050
3	5	-0.850	0.036
3	7	-0.975	0.012
5	6	0.700	0.012
6	7	-0.825	0.001

Delay 2

(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	3	1.026	0.001
1	6	0.947	0.022
2	3	0.816	0.001
2	6	0.737	0.038
3	5	-1.026	0.000
3	7	-1.000	0.004
5	6	0.947	0.003
6	7	-0.921	0.007

Delay 3

(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	3	0.757	0.032
1	6	1.000	0.005
2	3	0.757	0.028
2	6	1.000	0.001
3	4	-0.784	0.006
3	5	-1.027	0.000
4	6	1.027	0.001
5	6	1.270	0.000

Delay 4

(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	3	1.027	0.000
1	6	1.297	0.000
6	7	-1.162	0.000

Table D 2 Continued

Delay 5				Delay 6			
(I) SF	(J) SF	Mean (I-J)	Sig.(p)	(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	2	1.250	0.001	1	6	0.972	0.007
1	3	1.472	0.001	2	3	0.833	0.012
1	5	1.111	0.037	2	6	0.806	0.029
1	6	1.500	0.000	3	5	-1.194	0.004
6	7	-0.889	0.007	4	6	0.694	0.022
				5	6	1.167	0.000

Delay 7			
(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	2	0.472	0.010
1	3	0.806	0.006
2	4	-0.528	0.013
3	4	-0.861	0.006
3	5	-0.861	0.031

APPENDIX E

OWNERS AND CONTRACTOR

Table E 1 Owners and Contractors (SF's and Group Effects)

Delay 1							Delay 2					
	Owner		Contractor		Marginal			Owner		Contractor		Marginal
	(n=9)		(n=12)					n=17		n=27		
SF	$\bar{x}$	St.D.	$\bar{x}$	St.D.	M		SF	$\bar{x}$	St.D.	$\bar{x}$	St.D.	M
1	4.44	0.53	4.50	0.67	4.47		1	3.94	0.89	4.44	0.75	4.19
2	3.67	1.12	3.17	1.47	3.42		2	3.17	1.28	3.44	1.21	3.31
3	2.89	1.27	2.58	1.44	2.74		3	2.58	1.27	2.81	1.35	2.70
4	3.78	0.97	3.42	1.51	3.60		4	2.94	1.24	3.62	1.39	3.29
5	4.33	0.71	3.83	1.40	4.08		5	3.23	1.14	3.92	1.32	3.58
6	3.78	0.67	2.75	1.22	3.26		6	2.88	1.11	3.22	1.15	3.05
7	4.00	0.50	3.25	1.48	3.63		7	3.29	1.57	3.85	1.32	3.57
M	3.84		3.36				M	3.15		3.62		

Where
SF: Success Factors , St.D.: Standard Deviation
Marginal or (M): accumulative mean by raw (SF's effect) or column (group effect)

Table E 1 Continued

Delay 3							Delay 4					
	n=10		n=20					n=18		n=16		
SF	$\bar{x}$	St.D.	$\bar{x}$	St.D.	M		SF	$\bar{x}$	SD	$\bar{x}$	St.D.	M
1	3.70	1.06	4.35	0.59	4.03		1	4.28	0.89	4.25	0.77	4.26
2	2.90	1.66	4.00	1.03	3.45		2	3.22	1.06	3.06	1.34	3.14
3	2.60	1.07	3.00	1.34	2.80		3	3.00	1.28	2.63	1.45	2.81
4	3.30	1.06	4.00	0.79	3.65		4	3.72	1.27	3.81	1.38	3.77
5	3.60	1.07	4.20	1.06	3.90		5	3.83	1.20	4.13	1.31	3.98
6	3.20	0.79	3.15	0.93	3.18		6	3.28	1.13	3.19	0.98	3.23
7	3.60	0.84	3.75	1.07	3.68		7	3.50	1.15	3.69	1.20	3.59
M	3.27		3.78				M	3.55		3.54		

Where
SF: Success Factors , St.D.: Standard Deviation
Marginal or (M): accumulative mean by raw (SF's effect) or column (group effect)

Table E 1 Continued

Delay 5					
	n=11		n=14		
SF	$\bar{x}$	St.D.	$\bar{x}$	St.D.	Marginal
1	3.73	1.01	4.43	0.65	4.08
2	3.00	1.10	3.43	1.34	3.21
3	2.64	1.12	2.64	1.55	2.64
4	3.00	1.10	4.00	1.11	3.50
5	3.18	1.17	3.71	1.27	3.45
6	3.18	0.87	3.21	1.05	3.20
7	3.27	1.10	3.50	1.02	3.39
M	3.14		3.56		

Delay 6					
	n=9		n=19		
SF	$\bar{x}$	St.D.	$\bar{x}$	St.D.	Marginal
1	3.11	0.93	4.32	0.67	3.71
2	3.00	1.12	4.05	0.91	3.53
3	2.78	1.20	3.00	1.33	2.89
4	2.56	1.01	4.00	1.33	3.28
5	3.00	1.12	4.42	1.17	3.71
6	2.89	1.17	3.26	0.87	3.08
7	3.33	1.12	4.05	1.18	3.69
M	2.95		3.87		

Delay 7					
	Owner		Contractor		Marginal
	n=17		n=20		
SF	$\bar{x}$	St.D.	$\bar{x}$	St.D.	M
1	3.76	1.15	4.30	0.80	4.03
2	2.94	0.97	3.60	1.19	3.27
3	2.71	0.92	2.55	1.50	2.63
4	3.41	1.18	3.90	1.07	3.66
5	3.59	1.28	4.30	1.13	3.94
6	3.53	0.94	3.20	1.28	3.36
7	3.65	1.17	3.70	1.42	3.67
M	3.37		3.65		

Where
SF: Success Factors
$\bar{x}$: Mean
St.D.: Standard Deviation
Marginal or (M): accumulative mean by raw (SF's effect) or column (group effect)

Table E 2 Owners and Contractors - Main effects- Calculation

Delay 1						Delay 2					
Source	SS	d.f.	MS	F	Sig. (p)	Source	SS	d.f.	MS	F	Sig. (p)
SF	38.837	6	6.47	10.08	0.00	SF	55.05	6	9.176	11.381	0.00
SF X G	3.626	6	0.60	0.941	0.46	SF X G	2.31	6	0.386	.479	0.824
Error	73.190	114	0.64			Error	203.17	252	0.806		
GROUP	8.438	1	8.43	1.489	0.23	GROUP	15.97	1	15.979	2.736	0.106
Error	107.698	19	5.66			Error	245.27	42	5.840		
Delay 3						**Delay4**					
Source	SS	df	MS	F	Sig. (p)	Source	SS	df	MS	F	Sig. (p)
SF	28.86	6	4.81	6.6	0.00	SF	52.63	6	8.77	10.31	0.00
SF X G	5.78	6	0.96	1.33	0.244	SF X G	2.56	6	0.43	0.50	0.806
Error	121.11	168	0.72			Error	163.34	192	0.85		
GROUP	12.00	1	12.0	3.78	0.062	GROUP	0.01	1	0.01	0.00	0.967
Error	88.83	28	3.17			Error	151.36	32	4.73		

Where :
SF Success factors
SFXG: Success factors by group (interaction)
Group: Group main Effect
SS: Sum of squares
df: degree of freedom
MS: Mean squire

Table E - 2 Continued

Delay 5							Delay 6					
Source	SS	df	MS	F	Sig. (p)		Source	SS	df	MS	F	Sig. (p)
SF	27.33	6	4.55	5.747	0.000		SF	16.52	6	2.75	3.123	0.006
SF X G	4.84	6	0.80	1.019	0.416		SF X G	8.85	6	1.47	1.673	0.131
Error	109.40	138	0.79				Error	137.616	156	0.88		
GROUP	7.54	1	7.54	1.817	0.191		GROUP	36.16	1	36.16	11.717	0.002
Error	95.56	23	4.15				Error	80.25	26	3.08		
Delay 7												
Source	SS	df	MS	F	Sig. (p)		Where : SF Success factors SFXG: Success factors by group (interaction) Group: Group main Effect SS: Sum of squares df: degree of freedom MS: Mean squire					
SF	50.20	6	8.36	11.268	0.000							
SF X G	9.66	6	1.61	2.169	0.047							
Error	155.93	210	0.74									
GROUP	5.05	1	5.05	1.009	0.322							
Error	175.29	35	5.00									

Table E - 3 Owners and Contractors – Post hoc

Delay 1

(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	3	1.736	0.000
1	6	1.208	0.005
3	4	-0.861	0.018
3	5	-1.347	0.006
3	7	-0.889	0.038
5	6	0.819	0.032

Delay 2

(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	2	0.882	0.009
1	3	1.491	0.000
1	4	0.907	0.003
1	6	1.141	0.000
3	5	-0.879	0.001
3	7	-0.871	0.001
5	6	0.528	0.022

Delay 3

(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	3	1.225	0.005
1	6	0.850	0.003
3	4	-0.850	0.003
3	5	-1.100	0.005
3	7	-0.87	0.030

Delay 4

(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	2	1.122	0.004
1	3	1.451	0.000
1	6	1.031	0.001
2	5	-0.837	0.009
3	4	-0.955	0.044
3	5	-1.167	0.000
3	7	-0.781	0.019
5	6	0.747	0.012

Table E - 3 Continued

Delay 5				Delay 6			
(I) SF	(J) SF	Mean (I-J)	Sig. (p)	(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	3	1.438	0.006				
1	4	0.578	0.042	No significant Success Factors			
1	6	0.880	0.008				
1	7	0.692	0.037				

Delay 7			
(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	2	0.762	0.001
1	3	1.404	0.000
1	6	0.668	0.014
2	5	-0.674	0.004
3	4	-1.028	0.000
3	5	-1.316	0.000
3	7	-1.046	0.016
5	6	0.579	0.025

APPENDIX F

OWNERS, CONTRACTORS, AND ENGINEERS

Table F - 1 Owners, Contractors and Engineers – (SF's and Group Effects)

Delay 1							
	Owners		Contractors		Engineers		
	n=9		n=12		n=40		
SF	$\bar{x}$	St.D	$\bar{x}$	St.D	$\bar{x}$	St.D	M
1	4.44	0.53	4.50	0.67	4.50	0.85	4.48
2	3.67	1.12	3.17	1.47	3.65	1.19	3.49
3	2.89	1.27	2.58	1.44	3.13	1.36	2.87
4	3.78	0.97	3.42	1.51	3.63	1.29	3.61
5	4.33	0.71	3.83	1.40	3.98	1.07	4.05
6	3.78	0.67	2.75	1.22	3.28	1.13	3.27
7	4.00	0.50	3.25	1.48	4.10	0.93	3.78
M	3.84		3.36		3.75		

Delay 2							
	Owner		Contractor		Engineer		
	n=17		n=27		n=38		
SF	$\bar{x}$	St.D	$\bar{x}$	St.D	$\bar{x}$	St.D	M
1	3.94	0.90	4.44	0.75	4.16	1.10	4.18
2	3.18	1.29	3.44	1.22	3.95	0.90	3.52
3	2.59	1.28	2.81	1.36	3.13	1.30	2.84
4	2.94	1.25	3.63	1.39	3.53	1.35	3.37
5	3.24	1.15	3.93	1.33	4.16	1.17	3.77
6	2.88	1.11	3.22	1.15	3.21	1.32	3.11
7	3.29	1.57	3.85	1.32	4.13	1.09	3.76
M	3.15		3.62		3.75		

Where
SF: Success Factors , St.D.: Standard Deviation, $\bar{x}$: Mean
and Marginal or (M): accumulative mean by raw (SF's effect) or column (Group effect)

Table F - 1 Continued

Delay 3									Delay 4							
	Owners		Contractors		Engineers					Owner		Contractor		Engineer		
	n=10		n=20		n=37					n=18		n=16		n=37		
SF	$\bar{x}$	St.D	$\bar{x}$	St.D	$\bar{x}$	St.D	M		SF	$\bar{x}$	St.D	$\bar{x}$	St.D	$\bar{x}$	St.D	M
1	3.70	1.06	4.35	0.59	4.24	0.89	4.10		1	4.28	0.89	4.25	0.77	4.14	0.95	4.22
2	2.90	1.66	4.00	1.03	4.24	0.80	3.71		2	3.22	1.06	3.06	1.34	3.68	1.29	3.32
3	2.60	1.07	3.00	1.34	3.49	1.30	3.03		3	3.00	1.28	2.63	1.45	3.11	1.45	2.91
4	3.30	1.06	4.00	0.79	4.27	1.02	3.86		4	3.72	1.27	3.81	1.38	3.62	1.36	3.72
5	3.60	1.07	4.20	1.06	4.51	0.65	4.10		5	3.83	1.20	4.13	1.31	3.30	1.53	3.75
6	3.20	0.79	3.15	0.93	3.24	1.48	3.20		6	3.28	1.13	3.19	0.98	2.84	1.42	3.10
7	3.60	0.84	3.75	1.07	3.95	1.18	3.77		7	3.50	1.15	3.69	1.20	4.00	1.13	3.73
M	3.27		3.78		3.99				M	3.55		3.54		3.53		

Where

SF: Success Factors , St.D.: Standard Deviation, $\bar{x}$: Mean
and Marginal or (M): accumulative mean by raw (SF's effect) or column (Group effect)

Table F - 1 Continued

Delay5							
	Owners		Contractors		Engineers		
	n=11		n =14		n=36		
SF	$\bar{x}$	St.D	$\bar{x}$	St.D	$\bar{x}$	St.D	M
1	3.73	1.01	4.43	0.65	4.33	0.72	4.16
2	3.00	1.10	3.43	1.34	3.08	1.46	3.17
3	2.64	1.12	2.64	1.55	2.86	1.50	2.71
4	3.00	1.10	4.00	1.11	3.67	1.49	3.56
5	3.18	1.17	3.71	1.27	3.22	1.57	3.37
6	3.18	0.87	3.21	1.05	2.83	1.40	3.08
7	3.27	1.10	3.50	1.02	3.72	1.26	3.50
M	3.14		3.56		3.39		

Delay 6							
	Owner		Contractor		Engineer		
	n=9		n=19		n=36		
SF	$\bar{x}$	St.D	$\bar{x}$	St.D	$\bar{x}$	St.D	M
1	3.11	0.93	4.32	0.67	3.97	1.30	3.80
2	3.00	1.12	4.05	0.91	3.81	1.17	3.62
3	2.78	1.20	3.00	1.33	2.97	1.54	2.92
4	2.56	1.01	4.00	1.33	3.69	1.37	3.42
5	3.00	1.12	4.42	1.17	4.17	1.08	3.86
6	2.89	1.17	3.26	0.87	3.00	1.37	3.05
7	3.33	1.12	4.05	1.18	3.56	1.34	3.65
M	2.95		3.87		3.60		

Delay7							
	Owners		Contractors		Engineers		
	n=11		n=14		n=36		
SF	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	M
1	3.76	1.15	4.30	0.80	4.31	0.92	4.12
2	2.94	0.97	3.60	1.19	3.83	1.08	3.46
3	2.71	0.92	2.55	1.50	3.50	1.21	2.92
4	3.41	1.18	3.90	1.07	4.36	0.76	3.89
5	3.59	1.28	4.30	1.13	4.36	0.87	4.08
6	3.53	0.94	3.20	1.28	4.03	1.13	3.59
7	3.65	1.17	3.70	1.42	4.14	1.10	3.83
M	3.37		3.65		4.08		

Where

SF: Success Factors , St.D.: Standard Deviation, $\bar{x}$ Mean
and Marginal or (M): accumulative mean by raw (SF's effect) or column (group effect)

Table F - 2 Owners, Contractors and Engineers - Main Effects Calculations

Delay 1							Delay 2					
Source	SS	df	MS	F	Sig. (p)		Source	SS	df	MS	F	Sig. (p)
SF	67.85	6	11.30	13.94	0.00		SF	89.07	6	14.84	18.56	0.00
SF X G	7.70	12	0.642	0.791	0.66		SF X G	10.19	12	0.85	1.06	0.39
Error	282.38	348	0.811				Error	379.17	474	0.80		
GROUP	11.75	2	5.87	1.37	0.26		GROUP	30.01	2	15.01	2.73	0.07
Error	247.91	58	4.27				Error	433.76	79	5.49		
Delay 3							Delay 4					
Source	SS	df	MS	F	Sig. (p)		Source	SS	df	MS	F	Sig. (p)
SF	53.43	6	8.90	12.28	0.00		SF	75.23	6	12.54	12.36	0.00
SF X G	11.18	12	0.932	1.28	0.22		SF X G	23.40	12	1.95	1.92	0.03
Error	278.38	384	0.72				Error	413.63	408	1.01		
GROUP	28.99	2	14.49	4.11	0.02		GROUP	.044	2	0.022	0.004	0.99
Error	225.67	64	3.52				Error	338.51	68	4.97		

Where :
SF Success factors
SFXG: Success factors by group (Interaction)
Group: Group main Effect
SS: Sum of squares
df: degree of freedom
MS: Mean squire

Table F - 2 Continued

Delay 5						Delay 6					
Source	SS	df	MS	F	Sig. (p)	Source	SS	df	MS	F	Sig. (p)
SF	58.54	6	9.75	8.05	0.00	SF	37.65	6	6.27	6.32	0.00
SF X G	11.25	12	0.93	0.77	0.67	SF X G	11.48	12	0.95	0.96	0.48
Error	421.58	348	1.21			Error	363.44	366	0.99	363.44	
GROUP	7.56	2	3.78	0.90	0.41	GROUP	36.20	2	18.10	3.95	0.02
Error	242.87	58	4.18			Error	279.54	61	4.58		

Delay 7					
Source	SS	df	MS	F	Sig. (p)
SF	69.91	6	11.65	16.94	0.000
SF X G	14.49	12	1.20	1.75	0.053
Error	288.75	420	0.68		
GROUP	44.27	2	22.13	5.20	0.008
Error	298.00	70	4.25		

Where
SF Success factors
SFXG: Success factors by group (Interaction)
Group: Group main Effect
SS: Sum of squares
df: degree of freedom
MS: Mean squire

Table F - 3 Owners, Contractors and Engineers – Post hoc

Delay 1					Delay 2			
(I) SF	(J) SF	Mean (I-J)	Sig.(p)		(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	2	0.987	0.000		1	2	0.658	0.000
1	3	1.616	0.000		1	3	1.336	0.000
1	4	0.875	0.003		1	4	0.815	0.000
1	6	1.214	0.000		1	6	1.076	0.000
1	7	0.698	0.000		2	3	0.678	0.000
2	3	0.629	0.039		3	4	-0.521	0.010
3	4	-0.741	0.006		3	5	-0.928	0.000
3	5	-1.181	0.000		3	7	-0.914	0.000
3	7	-0.918	0.005		5	6	0.668	0.000
5	6	0.780	0.001		6	7	-0.654	0.000
6	7	-0.516	0.030					
Delay 3					Delay 4			
(I) SF	(J) SF	Mean (I-J)	Sig.(p)		(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	3	1.069	0.000		1	2	0.901	0.000
1	6	0.900	0.000		1	3	1.310	0.000
2	3	0.686	0.006		1	6	1.120	0.000
3	4	-0.828	0.000		3	4	-0.808	0.004
3	5	-1.076	0.000		3	5	-0.841	0.000
3	7	-0.736	0.010		3	7	-0.818	0.001
4	6	0.659	0.013		4	6	0.618	0.038
5	6	0.907	0.000		5	6	0.651	0.003
					6	7	0.628	0.002

Table F - 3 Continued

Delay 5				Delay 6			
(I) SF	(J) SF	Mean (I-J)	Sig. (p)	(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	2	0.992	0.001	1	3	0.883	0.013
1	3	1.450	0.000	1	6	0.749	0.006
1	6	1.087	0.000	2	3	0.703	0.011
1	7	0.665	0.016	3	5	-0.946	0.003
3	4	-0.842	0.013	5	6	0.812	0.001
3	5	-0.659	0.012	6	7	-0.596	0.015

Delay 7			
(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	2	0.665	0.000
1	3	1.205	0.000
1	6	0.538	0.000
2	3	0.540	0.009
2	4	-0.433	0.011
2	5	-0.625	0.000
3	4	-0.972	0.000
3	5	-1.164	0.000
3	6	-0.667	0.002
3	7	-0.910	0.001
5	6	0.497	0.011

APPENDIX G

AVERAGE GROUP WITH ENGINEERS

Table G - 1 Average Group with Engineers – (SF's and Group Effects)

Delay 1							Delay 2					
	Specific		Engineers		Marginal			Specific		Engineers		Marginal
	n=15		n=40					n=29		n=38		
SF	$\bar{x}$	St.D	$\bar{x}$	St.D	M		SF	$\bar{x}$	St.D	$\bar{x}$	St.D	M
1	4.47	0.61	4.50	0.85	4.48		1	4.28	0.73	4.16	1.10	4.22
2	3.63	1.04	3.65	1.19	3.64		2	3.34	1.09	3.95	0.90	3.65
3	2.77	1.25	3.13	1.36	2.95		3	2.72	1.11	3.13	1.30	2.93
4	3.60	1.11	3.63	1.29	3.61		4	3.40	1.26	3.53	1.35	3.46
5	4.03	1.03	3.98	1.07	4.00		5	3.69	1.29	4.16	1.17	3.92
6	3.23	1.00	3.28	1.13	3.25		6	3.10	1.02	3.21	1.32	3.16
7	3.63	1.09	4.10	0.93	3.87		7	3.72	1.18	4.13	1.09	3.93
M	3.62		3.75				M	3.47		3.75		

Where
SF: Success Factors
St.D: Standard Deviation, $\bar{x}$: Mean
Marginal or (M): accumulative mean by raw (SF's effect) or column (Group effect)

Table G - 1 Continued

Delay 3							Delay 4					
	n=24		n=37					n=21		n=37		
SF	$\bar{x}$	St.D	$\bar{x}$	St.D	M		SF	$\bar{x}$	St.D	$\bar{x}$	St.D	M
1	4.10	0.83	4.24	0.89	4.17		1	4.33	0.70	4.14	0.95	4.23
2	3.67	1.32	4.24	0.80	3.95		2	3.24	1.03	3.68	1.29	3.46
3	3.00	1.26	3.49	1.30	3.24		3	2.90	1.21	3.11	1.45	3.01
4	3.77	0.91	4.27	1.02	4.02		4	3.81	1.23	3.62	1.36	3.72
5	4.00	1.01	4.51	0.65	4.26		5	4.00	1.06	3.30	1.53	3.65
6	3.17	0.78	3.24	1.48	3.20		6	3.31	0.75	2.84	1.42	3.07
7	3.71	0.94	3.95	1.18	3.83		7	3.60	0.96	4.00	1.13	3.80
M	3.63		3.99				M	3.60		3.53		

Where
SF: Success Factors
St.D: Standard Deviation, $\bar{x}$: Mean
Marginal or (M): accumulative mean by raw (SF's effect) or column (Group effect)

Table G- 1 Continued

Delay 5					
	n=17		n=36		
SF	$\bar{x}$	SD	$\bar{x}$	SD	Marginal
1	4.03	0.93	4.33	0.72	4.18
2	3.24	1.23	3.08	1.46	3.16
3	2.62	1.34	2.86	1.50	2.74
4	3.56	1.17	3.67	1.49	3.61
5	3.35	1.21	3.22	1.57	3.29
6	3.00	0.90	2.83	1.40	2.92
7	3.26	1.06	3.72	1.26	3.49
M	3.29		3.39		

Delay 6					
	n=21		n=36		
SF	$\bar{x}$	SD	$\bar{x}$	SD	Marginal
1	3.98	0.84	3.97	1.30	3.97
2	3.83	0.89	3.81	1.17	3.82
3	3.02	1.04	2.97	1.54	3.00
4	3.67	1.21	3.69	1.37	3.68
5	4.00	1.22	4.17	1.08	4.08
6	3.12	0.86	3.00	1.37	3.06
7	3.88	0.88	3.56	1.34	3.72
M	3.64		3.60		

Delay 7					
	Specific		Engineers		
	(n=27)		(n=36)		
SF	$\bar{x}$	SD	$\bar{x}$	SD	Marginal
1	3.98	0.99	4.31	0.92	4.14
2	3.24	1.06	3.83	1.08	3.54
3	2.56	1.20	3.50	1.21	3.03
4	3.61	1.12	4.36	0.76	3.99
5	3.83	1.26	4.36	0.87	4.10
6	3.22	1.08	4.03	1.13	3.63
7	3.48	1.26	4.14	1.10	3.81
M	3.42		4.08		

Where
SF: Success Factors
St.D: Standard Deviation
$\bar{x}$: mean
Marginal or (M): accumulative mean by raw (SF's effect) or column (group effect)

Table G - 2 Average Group with Engineers - Main Effects Calculations

Delay 1							Delay 2					
Source	SS	df	MS	F	Sig. (p)		Source	SS	df	MS	F	Sig. (p)
SF	65.94	6	10.99	13.69	0.00		SF	83.00	6	13.835	18.982	0.00
SF X G	2.63	6	0.44	0.55	0.77		SF X G	6.29	6	1.049	1.439	0.19
Error	255.26	318	0.80				Error	284.25	390	0.729		
GROUP	1.216	1	1.21	0.32	0.572		GROUP	9.44	1	9.441	1.904	0.172
Error	199.03	53	3.75				Error	322.24	65	4.958		
Delay 3												
Source	SS	df	MS	F	Sig. (p)		Source	SS	df	MS	F	Sig. (p)
SF	63.16	6	10.52	15.038	0.00		SF	58.76	6	9.794	10.28	0.00
SF X G	3.64	6	0.60	0.866	0.52		SF X G	15.40	6	2.567	2.70	0.01
Error	247.82	354	0.70				Error	320.19	336	0.953		
GROUP	13.30	1	13.30	3.636	0.06		GROUP	0.50	1	0.507	0.11	0.74
Error	215.88	59	3.65				Error	259.83	56	4.640		

Where
SF Success factors
SFXG: Success factors by group (interaction)
Group: Group main Effect
SS: Sum of squares
df: degree of freedom
MS: Mean squire

Table G - 2 Continued

Delay 5							Delay 6					
Source	SS	df	MS	F	Sig. (p)		Source	SS	df	MS	F	Sig. (p)
SF	63.79	6	10.633	8.460	0.00		SF	58.052	6	9.675	10.50	0.00
SF X G	4.361	6	0.727	0.578	0.74		SF X G	1.806	6	0.301	0.327	0.92
Error	384.56	306	1.257				Error	304.04	330	0.921		
GROUP	0.726	1	0.726	0.170	0.68		GROUP	0.211	1	0.211	0.044	0.83
Error	217.88	51	4.272				Error	262.286	55	4.769		
Delay 7												
Source	SS	df	MS	F	Sig. (p)							
SF	56.61	6	9.435	14.375	0.00							
SF X G	3.78	6	0.630	0.960	0.45							
Error	240.22	366	0.656									
GROUP	46.67	1	46.676	11.277	0.00							
Error	252.47	61	4.139									

Where :
SF Success factors
SFXG: Success factors by group (interaction)
Group: Group main Effect
SS: Sum of squares
df: degree of freedom
MS: Mean squire

Table G - 3 Average Group with Engineers - Post-hoc

Delay 1					Delay 2			
(I) SF	(J) SF	Mean (I-J)	Sig.(p)		(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	2	0.842	0.001		1	2	0.571	0.002
1	3	1.537	0.000		1	3	1.289	0.000
1	4	0.871	0.001		1	4	0.755	0.000
1	6	1.229	0.000		1	6	1.060	0.000
1	7	0.617	0.001		2	3	0.718	0.000
2	3	0.696	0.013		3	4	-0.534	0.005
3	4	-0.667	0.015		3	5	-0.996	0.000
3	5	-1.058	0.000		3	7	-1.000	0.000
3	7	-0.921	0.004		4	5	-0.462	0.030
5	6	0.750	0.001		5	6	0.767	0.000
5	7	-.0612	0.004		6	7	-0.771	0.000
Delay 3					Delay 4			
(I) SF	(J) SF	Mean (I-J)	Sig.(p)		(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	3	0.930	0.000		1	2	0.777	0.001
1	6	0.969	0.000		1	3	1.228	0.000
2	3	0.712	0.002		1	6	1.161	0.000
2	6	0.750	0.003		3	4	-0.709	0.023
3	4	-0.777	0.000		3	5	-0.642	0.018
3	5	-1.014	0.000		3	7	-0.791	0.006
4	6	0.816	0.000		4	6	0.642	0.029
5	6	1.052	0.000		5	6	0.575	0.023
6	7	-0.622	0.021		6	7	-0.724	0.001

Table G - 3 Continued

Delay 5			
(I) SF	(J) SF	Mean (I-J)	Sig. (p)
1	2	1.022	0.001
1	3	1.442	0.000
1	5	0.894	0.029
1	6	1.265	0.000
1	7	0.688	0.020
3	4	-0.873	0.011
6	7	-0.577	0.043

Delay 6			
(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	3	0.976	0.001
1	6	0.915	0.000
2	3	0.821	0.000
2	6	0.760	0.002
3	5	-1.085	0.000
3	7	-0.720	0.047
4	6	0.621	0.013
5	6	1.024	0.000
6	7	-0.659	0.001

Delay 7			
(I) SF	(J) SF	Mean (I-J)	Sig.(p)
1	2	0.606	0.000
1	3	1.116	0.000
1	6	0.519	0.001
2	3	0.509	0.014
2	4	-0.449	0.006
2	5	-0.560	0.002
3	4	-0.958	0.000
3	5	-1.069	0.000
3	6	-0.597	0.006
3	7	-0.782	0.007

APPENDIX H

SPECIFIC PROJECT SURVEY

Success and Delay Factors in Saudi Arabian Public Projects **Specific Project Survey**

To the respondents:

This survey is part of academic research that aims to understand the relationship between the success and delay factors in construction projects. As a part of this research, the principal success and delay factors in construction projects in Saudi Arabia and other countries all over the world were studied. With this survey, we would like to investigate the relationships between these factors in order to improve the construction delivery_process. In the long term, this research could help the contract parties complete the project on time, within budget, and with the highest quality. All the information you provide will be kept in strict confidentiality and it will be used only for academic research

Please answer each question carefully. There is no right or wrong answer. If you are unsure of an answer, please respond with your best estimate.

There are **6** parts to this survey and a total of **17** pages. Please have two survey forms returned for each project: one from the owner and the other from the contractor. All respondents should answer all relevant sections.

For your convenience, there are two ways to respond to this survey. We would prefer that you respond **online** at www.surveymonkey.com/english/1, or Arabic version on www.surveymonkey.com/arabic/1 but you can also return a **hard copy** to the address below. Finally please don't hesitate to contact the researcher if you need any further clarification.

Part 1. Project Information

Project number: ___/___/________ **Project name:** __________________
Location of project (city): ____
Respondent who provided data, **Name:** ________________________________
Company or organization name: _____________________________________
Business address: ____
City: ____
Zip Code:__________________**Web site:** _______________________________
E-mail address: ____
Business telephone: _________________________**Fax:** ____________________
Are you a contractor's representative? _____or an owner's representative? __

Project type (select one)

☐ Office building
☐ Residential
☐ Hospital
☐ School
☐ Other, please specify: ___________________

Project gross area (square meters): ________ (m^2) **Number of floors**: _______

Was there an approved time extension for the project?

☐ No
☐ Yes, please specify length of extension: _________ (months) ________ (days)

Project's contract type:

☐ Lump sum
☐ Unit price
☐ other, please specify: __________________

Project designer:

☐ Owner, in-house
☐ Consultant
☐ Other, please specify: ____

Cost of project:

	Total Cost (SR)
Contracted	
Actual	

Project duration: ________________ (months) ________________________ (days)

	Start Date	Completion Date
Contracted		
Actual		

Part 2. Owner Information

If you are not an owner's representative please skip this part

Name of owner's organization: ____
Mailing address: ____
City: ____
Zip Code:__________________Web site: _______________________________________
E-mail address: ____
Business telephone: __________________________Fax: __________________________

Type of organization

☐ Military
☐ Municipal
☐ Educational
☐ Health Care
☐ Other, please specify: ________________________

Owner's experience with this type of project:

☐ Extensive experience
☐ Some experience
☐ Little or no experience

Which of the following best characterizes the availability of the owner's funding when the construction phase started?

☐ Completely available
☐ Partially available
☐ Not available
☐ Others, please specify: _____________________

Please rate the quality of each of the following:

	V. Good	Good	Fair	Poor	V. Poor
The working relationship among the members of the project's team (i.e., owner, consultants, and contractors' staff).					
The initiative of the contractor's site manager.					
The experience of the contractor's site engineer.					
The involvement of the contractor's site manager.					
The contractor's financial position during the construction phase					

Part 3. Contractor Information

If you are not a contractor's representative, please skip this part.

Name of contractor: ____
Mailing address: ____
City: ____
Zip Code:________________Web site: __________________________________
E-mail address: ____
Business telephone: ________________________Fax: _________________________
Contractor category (class) 1st _____2nd _____3rd __________ 4th ________________

Were the project payments on time?

☐ Yes
☐ No, payments were usually delayed approximately ________ month(s) ____ week(s)

Compared to contract specifications, how long did it take the owner or his representative to approve material samples or finished work?

☐ More quickly than specified in the contract
☐ Approximately the same amount of time as specified in the contract
☐ Longer than specified in the contract
☐ Other please specify: ___________________________

Please rate the quality of each of the following:

	V. Good	Good	Fair	Poor	V. Poor
The quality of the support and follow up for the project from the contractor's senior management					
The relationship among all the project team members (i.e., owner, consultants, and contractors staff)					
The cooperation of the owner or the owner's representative.					

Part 4. Project Factors Evaluation

Based on your experience with this project, please evaluate the overall quality of the following factors, and please add any other success or delay factors that you may have experienced in this project that are not included in this list.

Success factors	V. Good	Good	Fair	Poor	V. Poor
Organization planning efforts.					
Goal commitment of the project manager.					
Motivation and goal orientation of the project team.					
Clarity of the project scope and work definition.					
Capability and experience of the project manager.					
Safety record.					
The control system used for this project.					
Other ____________________					
Other ____________________					
Other ____________________					
Other ____________________					

Delay factors	V. Good	Good	Fair	Poor	V. Poor
Owner's cash availability during construction					
Timeliness of the owner's payments to the contractor					
Timeliness of decision making by owner					
Contractor's availability of funding during construction					
Design errors by designer					
Efficiency of project owner's operation (bureaucracy)					
Changes in types or specifications of construction material					
Other____________________________					
Other____________________________					
Other____________________________					
Other____________________________					

Part 5. Relationship between Success and Delay Factors

Below are a series of questions. Each set of items follows a similar format. In each set, you will be asked to indicate the extent to which one feature of the project could have been affected by several other project factors.

1. **In this project, did the owner experience any cash problems during construction?**
   No_________ (if no, please skip to question 2) Yes ___________

If yes, to what extent could the owner's cash problems during construction have been avoided and/or prevented by the:

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization's planning efforts.					
Project manager's goal commitment.					
Project team's motivation and goal orientation.					
Clarity of the project scope and work definition.					
Project manager's capabilities and experience.					
Safety precautions and applied procedures.					
Use of a control system.					
Other_______________________					
Other_______________________					
Other_______________________					

2. **In this project, did the contractor experience any delays in progress payments by the owner?**
   No_________ (if no, please skip to question 3)   Yes ___________

If yes, to what extent could the delays in progress payments to the contractor by the owner have been avoided and/or prevented by the:

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization's planning efforts.					
Project manager's goal commitment.					
Project team's motivation and goal orientation.					
Clarity of the project scope and work definition.					
Project manager's capabilities and experience.					
Safety precautions and applied procedures.					
Use of a control system.					
Other________________________					
Other________________________					
Other________________________					

3. **During this project, was there any slowness in the owner's decision making process?**
   No_________ (if no, please skip to question 4)   Yes ___________

If yes, to what extent could the slowness in the owner's decision-making process have been avoided and/or prevented by the:

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization's planning efforts.					
Project manager's goal commitment.					
Project team's motivation and goal orientation.					
Clarity of the project scope and work definition.					
Project manager's capabilities and experience.					
Safety precautions and applied procedures.					
Use of a control system.					
Other_______________________					
Other_______________________					
Other_______________________					

4. In this project, did the contractor experience any financial problems during construction?
No_________ (if no, please skip to question 5) Yes ___________

If yes, to what extent could the financial problems experienced by the contractor during construction have been avoided and/or prevented by the:

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization planning efforts					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and work definition					
Project manager's capabilities and experience					
Safety precautions and applied procedures.					
Use of a control system.					
Other___________________________					
Other___________________________					
Other___________________________					

5. **In this project, were there any design errors by the designer?**
No_________ (if no, please skip to question 6) Yes ___________

If yes, to what extent could the design errors made by the designer have been avoided and/or prevented by the:

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization planning efforts					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and work definition					
Project manager's capabilities and experience					
Safety precautions and applied procedures.					
Use of a control system.					
Other____________________________					
Other____________________________					
Other____________________________					

6. **In this project, was there excessive bureaucracy in the owner's operation?**
No_________ (if no, please skip to question 7) Yes ___________

If yes, to what extent could the excessive bureaucracy in the owner's operation have been avoided and/or prevented by the:

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization planning efforts					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and work definition					
Project manager's capabilities and experience					
Safety precautions and applied procedures.					
Use of a control system.					
Other____________________________					
Other____________________________					
Other____________________________					

7. **In this project did the project experience any changes in the types and or specifications of construction materials?**
No_________ (please skip to part 6) Yes ___________

If yes, to what extent could the changes in types and/or specifications of construction materials have been avoided and/or prevented by the:

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization planning efforts					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and work definition					
Project manager's capabilities and experience					
Safety precautions and applied procedures.					
Use of a control system.					
Other___________________________					
Other___________________________					
Other___________________________					

Part 6. Additional Causes of Delay

In your experience with this project, were there any other causes of delay that could have been avoided and prevented by any of listed success factors or others:

1. **Cause of delay: ______________________________could have been avoided and/or prevented by:**

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization planning efforts					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and work definition					
Project manager's capabilities and experience					
Safety precautions and applied procedures.					
Use of a control system.					
Other_________________________					
Other_________________________					
Other_________________________					

Part 6. Additional Causes of Delay

2. **Cause of delay: ______________________________could have been avoided and/or prevented by:**

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization planning efforts					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and work definition					
Project manager's capabilities and experience					
Safety precautions and applied procedures.					
Use of a control system.					
Other_________________________					
Other_________________________					
Other_________________________					

Part6. Additional Cause of Delay:

Please reprint this page and attach it to the survey if the project experienced more than 3 additional causes of delay.

3. **Cause of delay: ____________________________could have been avoided and/or prevented by:**

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization planning efforts					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and work definition					
Project manager's capabilities and experience					
Safety precautions and applied procedures.					
Use of a control system.					
Other___________________________					
Other___________________________					
Other___________________________					

Thank you very much we appreciate your valuable time

Please provide any additional information or comments you think are relevant:

1. ______________
2. ______________
3. ______________
4. ______________
5. ______________

Glossary of Terms

Part 1

- **Project gross area**: Total square meters of floor area constructed. In case the project is more than one floor, the total area is the sum of every floor.
- **Contracted cost**: Costs that were agreed upon when the contract was signed.
- **Actual cost**: Cost that represents the actual final costs spent by the owner on the project.
- **Contracted start and completion dates**: Indicate the dates that were planned to start and end the project.
- **Actual start and completion dates**: Indicate the actual beginning and ending dates of the project activities.

Part 4

- **Planning efforts**: Development of a good project plan through the judicious and adequate use of schedule networking techniques, scope and work definition, cash flow analysis, and risk identification.
- **Goal commitment of the project manager**: The project manager’s commitment to meeting cost, schedule, safety, and quality commitments.
- **Motivation and goal orientation of the project team:** The motivation of all the project personnel, particularly the supervisors, foremen, and field construction staff, with special reference to their commitment towards the goals of the project.
- **Project scope clarity and work definition:** The project scope and work definition with special reference to completeness, clarity, and changeability.
- **Capability and experience of the project manager:** The project manager’s experience and capabilities with particular reference to technical, administrative, human relations, and communication skills.
- **Safety precautions**: All aspects of safety, with particular reference to the implementation of safety programs, monitoring of safety, safety regulations and requirements written into contract documents, and safety-linked bonus schemes.
- **Control system**: Procedures implemented to track project progress relative to goals established in the planning phase.
- **Owner cash problems during construction**: The financial position of the owner prevented the owner from meeting the contract requirements.
- **Delays in progress payments to the contractor by the owner**: The actual payments were made later than the contract-specified time.
- **Slowness in owner's decision-making process**: The construction process was slowed by the owner’s delay in approving construction materials and completed work.
- **Financial problems by the contractor during construction:** The financial situation of the contractor during the construction phase prevented the contractor from meeting the contract requirements.
- **Changes in types and/or specifications of construction material**: Changes in specified material in contract documents due to design error, adaptation of new material, or other circumstances.

APPENDIX I

GENERAL SURVEY

Success and Delay Factors in Saudi Arabian Public Projects
General Survey

To the respondents:
This survey is part of academic research that aims to understand the relationship between the success and delay factors in construction projects. As a part of this research, the principal success and delay factors in construction projects in Saudi Arabia and other countries all over the world were studied. With this survey, we would like to investigate the relationships between these factors in order to improve the construction delivery process. In the long term, this research could help the contract parties complete the project on time, within budget, and with the highest quality. All the information you provide will be kept in strict confidentiality and it will be used only for academic research

Please answer each question carefully. There is no right or wrong answer. If you are unsure of an answer, please respond with your best estimate. There are **4** parts to this survey and a total of **16** pages. All respondents should answer all relevant sections.

For your convenience, there are two ways to respond to this survey. We would prefer that you respond **online** at www.surveymonkey.com/english/2, or Arabic version on www.surveymonkey.com/arabic/2, but you can also return a **hard copy** to the address below. Finally please don't hesitate to contact the researcher if you need any further clarification.

Part 1. Engineer's Information and general experience

Name: ___________________________ **website (if applicable):** ___________________
E Mail: _________________________ **Telephone:** ______________________________
Major: ___________________ **Qualifications**: Bachelor_____ Master ____others__
Degree Date: _____________ **Number of years in construction field:** _________ (yrs)
Employer: ___________________ **Work Location (city)**: _______________________

Please rank each of the following in terms of your level of previous professional experience. (1=most experience)

_____Design
_____Construction
_____Maintenance:
_____Other please specify____

Please rank each of the following project types in terms of your level of experience. (1=most experience)

_____Offices building _____School
_____Residential _____Other, please specify: ___________________
_____Hospital

Have you ever worked as a Site Engineer?

☐ Yes, please specify approximate number of projects _________________________
☐ No

Have you ever worked as a Project Manager?

☐ Yes, please specify approximate number of projects _________________________
☐ No

Based on your professional experience, in general what is the most successful method of construction projects design?

☐ In-house
☐ Consultant
☐ Other, please specify ____

Based on your professional experience, in general what is the most successful type of project contract?

☐ Lump Sum
☐ Unit Price
☐ Other, please specify ____

How much influence do you think bureaucracy has on the delay of construction projects in the Kingdom of Saudi Arabia?

☐ A very strong influence
☐ A strong influence
☐ A moderate influence
☐ A weak influence
☐ No influence

From your professional experience, compared to the contract specifications, how long does it generally take the owner or his representative to approve material samples, or finished work?

☐ Quicker (faster) than specified in the contract
☐ Approximately the same amount of time as specified in the contract
☐ Longer than specified in the contract
☐ Other, please specify____

From your professional experience, how much authority does the average project manager have in running a project?

☐ Complete authority
☐ Considerable authority
☐ Some authority
☐ Little authority
☐ No authority

From your professional experience in public projects in Saudi Arabia, please rate the quality of each of the following:

	V. Good	Good	Fair	Poor	V. Poor
The typical working relationship among project team members (i.e., owner, consultants, and contractors' staff).					
The typical level of cooperation of the owner or the owner's representatives.					
Support for the project, from the typical contractor's senior management.					
The safety precautions generally applied by the contractors					
The safety precautions generally applied by the owners					

Part 2. Project Factors Evaluation

Based on your overall professional experience in construction projects in Saudi Arabia, in general please evaluate the quality of the following project success or delay factors. Please add and evaluate any additional factors that you may have experienced to the list in the space provided.

Success factors	V. Good	Good	Fair	Poor	V. Poor
Organization planning efforts.					
Goal commitment of the project manager.					
Motivation and goal orientation of the project team.					
Clarity of the project scope and work definition.					
Capability and experience of the project manager.					
Safety record.					
The control system used for this project.					
Other ____________________					
Other ____________________					
Other ____________________					
Other ____________________					

Delay factors	V. Good	Good	Fair	Poor	V. Poor
Owner's cash availability during construction					
Timeliness of the owner's payments to the contractor					
Timeliness of decision making by owner					
Contractor's availability of funding during construction					
Design errors by designer					
Efficiency of project owner's operation (bureaucracy)					
Changes in types or specifications of construction material					
Other____________________________					
Other____________________________					
Other____________________________					
Other____________________________					

Part 3. Relationship between Success and Delay Factors

Below are a series of questions. Each set of items follows a similar format. In each set, you will be asked to indicate the extent to which one feature (delay factor) of the project could have been affected by several other project factors. There is a glossary provided at the end of this document to clarify terms.

1. **From your professional experience in the construction field, to what extent could an owner's cash problems during construction have been avoided and/or prevented by the factors listed below … (If there are other factors that could have prevented cash problems, please list and evaluate in the spaces provided below).**

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization planning efforts					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and work definition					
Project manager's capabilities and experience					
Safety precautions and applied procedures.					
Use of a control system.					
Other___________________________					
Other___________________________					
Other___________________________					

2. From your professional experience in the construction field, to what extent could the delays in progress payments to the contractor by the owner have been avoided and/or prevented by the:

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization planning efforts					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and work definition					
Project manager's capabilities and experience					
Safety precautions and applied procedures.					
Use of a control system.					
Other___________________________					
Other___________________________					
Other___________________________					

3. From your professional experience in the construction field to what extent could the slowness in the owner's decision-making process have been avoided and/or prevented by the:

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization planning efforts					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and work definition					
Project manager's capabilities and experience					
Safety precautions and applied procedures.					
Use of a control system.					
Other___________________________					
Other___________________________					
Other___________________________					

4. From your professional experience in the construction field to what extent could the financial problems experienced by the contractor during construction have been avoided and/or prevented by the:

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization planning efforts					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and work definition					
Project manager's capabilities and experience					
Safety precautions and applied procedures.					
Use of a control system.					
Other_________________________					
Other_________________________					
Other_________________________					

5. From your professional experience in the construction field to what extent could the design errors made by the designer have been avoided and/or prevented by the:

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization planning efforts					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and work definition					
Project manager's capabilities and experience					
Safety precautions and applied procedures.					
Use of a control system.					
Other__________________________					
Other__________________________					
Other__________________________					

6. From your professional experience in the construction field to what extent could the excessive bureaucracy in the owner’s operation have been avoided and/or prevented by the:

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization planning efforts					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and work definition					
Project manager's capabilities and experience					
Safety precautions and applied procedures.					
Use of a control system.					
Other_________________________					
Other_________________________					
Other_________________________					

7. From your professional experience in the construction field to what extent could the changes in types and/or specifications of construction materials have been avoided and/or prevented by the:

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization planning efforts					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and work definition					
Project manager's capabilities and experience					
Safety precautions and applied procedures.					
Use of a control system.					
Other_________________________					
Other_________________________					
Other_________________________					

Part 4. Additional Causes of Delay

From your professional experience, are there any other general causes of delay (not mentioned in the previous questions) that could have been avoided and prevented by either the listed success factors or others you have experienced?

1. Cause of delay: ______________________________could have been avoided and/or prevented by:

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization planning efforts					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and work definition					
Project manager's capabilities and experience					
Safety precautions and applied procedures.					
Use of a control system.					
Other________________________					
Other________________________					
Other________________________					

Part 4. Additional Cause of Delay:

1. **Cause of delay: ______________________________could have been avoided and/or prevented by:**

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization planning efforts					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and work definition					
Project manager's capabilities and experience					
Safety precautions and applied procedures.					
Use of a control system.					
Other_________________________					
Other_________________________					
Other_________________________					

Part 4. Additional Cause of Delay:

Please reprint this page and attach it to the survey if you want to list more additional causes of delay

2. **Cause of delay: ______________________________could have been avoided and/or prevented by:**

	Completely	A good deal	A moderate amount	A small amount	Not at All
Organization planning efforts					
Project manager's goal commitment					
Project team's motivation and goal orientation					
Clarity of project scope and work definition					
Project manager's capabilities and experience					
Safety precautions and applied procedures.					
Use of a control system.					
Other_______________________					
Other_______________________					
Other_______________________					

Glossary of terms

- **Planning efforts**: Development of a good project plan through the judicious and adequate use of schedule networking techniques, scope and work definition, cash flow analysis, and risk identification.
- **Goal commitment of the project manager**: The project manager’s commitment to meeting cost, schedule, safety, and quality commitments.
- **Motivation and goal orientation of the project team:** The motivation of all the project personnel, particularly the supervisors, foremen, and field construction staff, with special reference to their commitment towards the goals of the project.
- **Project scope clarity and work definition:** The project scope and work definition with special reference to completeness, clarity, and changeability.
- **Capability and experience of the project manager:** The project manager’s experience and capabilities with particular reference to technical, administrative, human relations, and communication skills.
- **Safety precautions**: All aspects of safety, with particular reference to the implementation of safety programs, monitoring of safety, safety regulations and requirements written into contract documents, and safety-linked bonus schemes.
- **Control system**: Procedures implemented to track project progress relative to goals established in the planning phase.
- **Owner cash problems during construction**: The financial position of the owner prevented the owner from meeting the contract requirements.
- **Delays in progress payments to the contractor by the owner**: The actual payments were made later than the contract-specified time.
- **Slowness in owner's decision-making process**: The construction process was slowed by the owner’s delay in approving construction materials and completed work.
- **Financial problems by the contractor during construction:** The financial situation of the contractor during the construction phase prevented the contractor from meeting the contract requirements.
- **Changes in types and/or specifications of construction material**: Changes in specified material in contract documents due to design error, adaptation of new material, or other circumstances

APPENDIX J

PRINCIPAL COMPONENT ANALYSIS SUMMARY

Success Factors		Delay Factors	
S1	Organization's planning efforts	D1	Owner's cash problems during construction
S2	Project manager's goal commitment	D2	Delays in contractor's progress payments by the owner?
S3	Project team's motivation and goal orientation	D3	Slowness in the owner's decision making process
S4	Clarity of the project scope and work definition	D4	Contractor's financial problems during construction
S5	Project manager's capabilities and experience	D5	Design errors made by the designer
S6	Safety precautions and applied procedures	D6	Excessive bureaucracy in the owner's operation
S7	Use of a control system	D7	Changes in types or specifications of construction material

Figure J - 1 Critical Success and Delay Factors

Table J - 1 Component analysis – Owners

	Delay 1			Delay 2		Delay 3		
	1	2	3	1	2	1	2	3
S1	0.522*	0.060	0.699	0.073	0.825	0.821	-0.511	-0.099
S2	0.528	0.458	0.555	0.864	0.208	0.721	0.253	0.059
S3	0.279	0.885	-0.008	0.746	-0.459	0.574	0.713	0.390
S4	0.475	0.599	-0.585	0.680	0.568	0.715	0.287	-0.572
S5	0.871	-0.009	-0.424	0.898	-0.088	0.864	-0.304	-0.343
S6	0.551	-0.666	-0.163	0.724	-0.553	0.539	-0.479	0.664
S7	0.833	-0.516	0.098	0.813	0.242	0.815	0.176	0.198

Table J - 1 Continued - Owners

	Delay 4		Delay 5		Delay 6		Delay 7	
	1	2	1	2	1	2	1	2
S1	0.269	0.498	0.732	-0.632	0.505	-0.358	0.951	-0.187
S2	0.829	0.030	0.795	0.554	0.829	-0.483	0.706	-0.199
S3	0.800	-0.233	0.732	0.563	0.223	-0.680	0.228	0.932
S4	0.370	0.816	0.771	-0.367	0.945	-0.139	0.933	0.193
S5	0.781	0.340	0.768	0.269	0.829	0.417	0.950	0.103
S6	0.767	-0.411	0.914	-0.145	0.888	0.348	0.802	0.098
S7	0.846	-0.265	0.900	-0.203	0.218	0.963	0.732	-0.342

Table J - 2 Component analysis – Contractors

	Delay 1		Delay 2		Delay 3		
	1	2	1	2	1	2	3
S1	0.024	0.976	0.267	0.881	0.225	0.249	0.911
S2	0.932	-0.097	0.617	-0.564	0.687	-0.523	0.308
S3	0.890	0.283	0.830	-0.018	0.813	-0.292	-0.330
S4	0.922	0.018	0.806	-0.148	0.813	-0.383	-0.134
S5	0.780	-0.319	0.850	0.060	0.732	0.425	0.113
S6	0.912	-0.059	0.882	0.131	0.207	0.815	-0.229
S7	0.971	0.104	0.885	0.091	0.608	0.612	-0.123

Table J - 2 Continued– Contractors

	Delay 4		Delay 5			Delay 6		Delay 7		
	1	2	1	2	3	1	2	2	1	2
S1	0.039	0.921	0.192	0.862	0.063	0.557	0.179	-0.633	0.576	-0.648
S2	0.593	-0.527	0.608	0.122	-0.716	0.454	-0.573	0.430	0.787	0.277
S3	0.688	0.069	0.646	-0.483	-0.391	0.716	-0.192	0.183	0.502	0.790
S4	0.870	-0.140	0.567	0.766	-0.042	0.717	-0.418	-0.386	0.614	0.439
S5	0.889	-0.070	0.716	-0.384	-0.092	0.814	0.164	0.044	0.877	-0.113
S6	0.766	0.346	0.532	-0.240	0.753	0.322	0.717	-0.061	0.701	-0.177
S7	0.899	0.164	0.823	0.049	0.443	0.498	0.468	0.577	0.823	-0.349

Table J - 3 Component analysis – Engineers

	Delay 1		Delay 2		Delay 3		Delay 4	
	1	2	1	2	1	2	1	2
S1	0.654	-0.560	0.680	-0.524	0.735	-0.381	0.515	-0.400
S2	0.584	0.297	0.822	-0.256	0.789	-0.333	0.630	-0.556
S3	0.507	0.788	0.727	0.367	0.633	0.614	0.751	-0.501
S4	0.641	0.324	0.777	0.407	0.790	0.149	0.740	0.250
S5	0.656	-0.164	0.775	-0.037	0.705	-0.349	0.757	0.164
S6	0.741	0.062	0.566	0.584	0.689	0.521	0.605	0.553
S7	0.688	-0.514	0.740	-0.431	0.589	-0.129	0.543	0.533

Table J 3 Continued – Engineers

	Delay 4		Delay 5			Delay 6		Delay 7		
S1	0.515	-0.400	-0.376	-0.105	0.817	0.640	-0.230	0.836	-0.181	0.131
S2	0.630	-0.556	0.774	-0.245	0.391	0.713	0.533	0.868	-0.139	-0.321
S3	0.751	-0.501	0.894	-0.016	-0.152	0.495	0.713	0.581	-0.572	-0.357
S4	0.740	0.250	0.648	-0.423	0.371	0.801	-0.066	0.687	0.518	-0.332
S5	0.757	0.164	0.778	0.162	-0.312	0.624	0.029	0.480	0.764	-0.102
S6	0.605	0.553	0.371	0.712	0.363	0.811	-0.203	0.851	-0.210	0.265
S7	0.543	0.533	0.055	0.867	0.148	0.731	-0.527	0.564	0.107	0.758

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