ASSESSMENT OF RISK MANAGEMENT PERCEPTIONS AND PRACTICES OF CONSTRUCTION CONTRACTORS IN SAUDI ARABIA

BY

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This thesis, written by **Ali Abdullah Al-Salman** under the direction of his Thesis Advisor and approved by his Thesis Committee, has been presented to and accepted by the Dean of Graduate Studies, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN CONSTRUCTION ENGINEERING & MANAGEMENT.**

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DEDICATED TO MY BELOVED PARENTS, WONDERFUL WIFE AND KIDS WHO ARE THE SOURCE OF MY INSPIRATION, ENCOURAGEMENT, GUIDANCE AND HAPPINESS

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THESIS ABSTRACT

Name of Student: **Ali Abdullah Al Salman**

Title of Study: **Assessment of Risks Management Perception and Practices of Construction Contractors in Saudi Arabia**

Major Field: **Construction Engineering and Management**

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This Thesis presents the details of a study on the assessment of risks management perception and practice of construction contractors in Saudi Arabia toward construction risks. Focuses on risk allocation (both contractors perception and as practiced); risk importance and risk effects on a construction project; and compares contractors' perception of allocating construction risks to the common practice of allocating these risks.

To achieve the study objectives the researcher conducted a literature review of the subject, defined important risk parameters and categories related to construction risks, designed a questionnaire related to allocation of risks, importance and effects of these risks on a construction projects. The questionnaire was distributed to 82 construction contractors of grade 1 and higher as per the classification of the Chamber of Commerce, Eastern Province Chapter.

Responses from 30 contractors were received, analyzed, summarized and reported. Analysis of the results indicated that the perception of construction contractors in Saudi Arabia in allocating surveyed risks is different from the common practice of allocating these risks. In practice, most of the risks are allocated to contractors and none to owners. Quality of work is the most important risk while adverse weather condition is the least important risk. The surveyed risks have the highest impact on the schedule of a project with a response frequency of 38.5% while the same risks affect the safety of the project least (only with a response frequency of 8.5%).

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خلاصة البحث

أسم الباحث: علـي عبدالله السلمان

عنوان البحث: تقييم ادارة المقاولين لمخاطرمقاولات التشييد و البناء

التخصص: ادارة و هندسة التشييد

تاريخ الشهادة : مايو- 2004 م

تستعرض هذه الدراسة نتائج البحث و التحليل لتقييم مفهوم و ممارسة مقاولي التشييد في المملكة العربية السعودية لادارة مخاطرمقاولات التشييد والبناء و ذلك بالتركيز على تخصيص المخاطر (حسب مفهوم المقاول و حسب ما هو ممارس ومتبع), اهمية المخاطر وتأثير هذه المخاطر على المشروع.

لبلوغ أهداف هذه الدراسة قام الباحث بدراسة شاملة و مراجعة الموضوع في النشرات و الدوريات و الكتب المتخصصة وتم تحديد وصف المخاطر المتعلقة بمقاولات التشييد و بعد ذلك تم اعداد استبيان عن تخصيص المخاطر , اهميتها و تأثيرها على مشاريع التشييد و البناء. تم توزيع الاستبيان على 82 مقاول تشييد (من الدرجة الاولى و ما فوق حسب تصنيف الغرفة التجارية بالمنطقة الشرقية).

تم استلام و تحليل ردود 30 مقاولا أكملو ألاستبيان. تحليل النَتائِج أشارَ بأنّ، مفهوم مقاولي البناء في المملكة العربية السعودية في تَخصيص المخاطرَ مختلفة عن التقليد المتَّبع في تَخصيص هذه المخاطر. عملياً، أغلب المخاطر تُخصّصُ إلى المقاولين ولا شيئ إلى المالكين. كذلك تبين ان جودة العمل هو الخطرُ الأكثر أهمية بينما حالة الطقس الغير ملائمة هي الخطر الاقل اهمية. تبين كذلك أن هذه المخاطر لها التأثيرُ الأعلى على جدول المشروع (بنسبة 38.5%) بينما نفس هذه المخاطر لها أقل تأثير على سلامةِ المشروع (تُؤثرُ فقط بنسبة 8.5%).

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 GENERAL

The construction process is one of the most risky and challenging industries. It has an inherited risk in all of the processes starting from the conceptual phase of a project, engineering design, placing the bid and going through scheduling, material procurement, construction, changing orders and ending with the commissioning, final payment and closing-up of the project. Risk in construction cannot be eliminated but can be managed once taken. It can be controlled, minimized, transferred or shared. For risk management, there is no single universal and systematic approach that can be followed to manage and control all risks associated with every construction project

Construction requires the application of different types of resources to see a finished facility such as a multi-story building, a processing plant, an airport or even a small room. These resources might include manpower, equipment and tools, money, time and basic construction materials. Each of these resources has some risks associated with it. For example, the risk of not completing the project as scheduled or on budget or any injuries or damage to the workforce and equipment means losses to the contractor as well as more losses and delays to the client. These resources, along with associated risks, should be identified and managed to minimize losses and increase profits.

The construction industry in Saudi Arabia is exposed to similar risks as in other parts of the world and also risks associated with the unique characteristics of the region and the local practices.

1.2 CHARACTERISTICS OF THE REGION

The Eastern Province of Saudi Arabia is characterized by its unique environmental conditions and industry growth that should be considered in assessing the construction risks, allocating these risks and selecting the appropriate risk management approaches.

1.2.1 Environmental Characteristics of the Region

This region is characterized by high temperatures and humidity conditions as well as large variation in the diurnal and seasonal temperature and humidity. The temperature can reach up to 50 °C and can vary by as much as 20 °C between day and night during a typical summer day and the relative humidity ranges from 40% to 100%. These sudden and continuous variations in the temperature and humidity affect the construction workers' productivity and this directly affects the project schedule and work quality which in turn affects the project cost and increases risks. This unique characteristic of the region should be considered in the safety/ hazards as well as in the schedule / cost estimates of a project to minimize the associated risks.

1.2.2 Construction Growth

Another characteristic of the region is the fast growth in construction since the discovery of oil in the region back in 1938. The oil and petrochemical industries have expanded greatly in the last two decades. The construction industry was given most of the government spending during the first five year plan (1970-1975), second (1975-1980) and the third (1980-1985) National development plans. It received 49.6%, 32% and 49.8 % respectively, of the total government expenditure during these plans. The oil and petrochemical industries continue to grow and expand to meet the potential new oil and gas discoveries in the region.

1.3 PROBLEM STATEMENT

The complex characteristics of major construction projects, competitions and the tight economic situations have created the necessity for predicting the project risks and the need to improve management support, techniques, and tools for risk management.

There is a lack of an accepted method of risk assessment and management among professionals in the construction industry compared with the financial and health professions (Mulholland 1999).

A 1992 worldwide survey reported that the majority of construction projects fail to achieve the objectives of the schedule (Cooper 1994).

This study is to shed some light on the perception and attitude of the typical construction contactor in the Eastern Province of Saudi Arabia towards construction risks. It is mainly concerned with the allocation of risks, risk importance and their effects on the project as well as the improvements of the understanding by local contractors of risks related to the construction industry.

1.4 RESEARCH OBJECTIVES

The objective is to investigate the assessments and management of construction risks. In particular, the research will:

1st. Present the perception and attitude of the typical construction contractor in the Eastern Province of Saudi Arabia towards construction risks. It is mainly concerned with the allocation of risks, risk importance and their effects on the project.

2nd. Compare the perception of the typical local construction contractor towards allocation of construction risks to the common practice of allocating these risks.

1.5 RESEARCH SCOPE AND LIMITATIONS

Although this research will be done in the Eastern Province of Saudi Arabia, the results and conclusions can be applied to the construction industry in other areas of Saudi Arabia because of the similarities of the rules, regulations and business environment. Moreover, most of the large construction contractors have offices in other areas of Saudi Arabia.
Because of the above reasons and for the purpose of this study, the words Easter Province of Saudi Arabia and Saudi Arabia will be used interchangeably.

This research will be limited to:

A. Medium to large construction contractors (Grades 1 or higher) per the classification of the Chamber of Commerce, Saudi Arabia Eastern Province Branch.

B. Limited to the construction contractors in the Eastern Province of Saudi Arabia.

C. Limited to general contractors lump sum type of construction contracts.

1.6 SIGNIFICANCE OF THIS STUDY

The construction industry is subject to more risks and uncertainties than any other industry. Projects in construction involve hundreds or even thousands of interacting activities, each with cost, time, quality and sequencing problems. Each of these activities carries some risks and uncertainties and if these risks are not managed properly, losses will take place. To minimize these losses, risks and uncertainties must be identified, classified, analyzed and administered. The way these risks are allocated, their importance and their effects on the project will outline the best techniques to be used for managing risks associated with the construction industry.

The construction industry in Saudi Arabia is one of the biggest and fastest growing industries, especially with the new discoveries of oil and natural gas fields. In 1998, the construction industry in Saudi Arabia employed 16% of the total labor force and accounted for an estimated 8.7% and approximately 8% of GDP (at current prices) in 1990 and 2000 respectively (The Economist Intelligence Uni Limited, 2001, seventh Development Plan, 2000). This study will shed some light on assessing the risk management practices of construction contractors in this part of the world. It will also help the local contractors identify the best approach to dealing with these risks.

Risk assessment in construction in Saudi Arabia is a new concept. In fact, during my literature review of the subject I could not find any previous

research done on this important subject. This study will shed some light on this issue of assessing the risk management practice in this region to help contractors minimize losses and clients to save the extra costs of their projects by better understanding how these risks are allocated and dealt with.

1.7 THESIS OUTLINE

This thesis is arranged in six chapters. Chapter one is an introduction chapter giving a general view of the construction industry, general and environmental characteristics of the region, construction growth in the area, problem statement, research objectives, research scope and limitations and significance of the study.

Chapter two will cover the literature review of the available work reported on the subject of risk management in the construction industry with emphasis on risk management, risk allocation and the importance of risks and risk responses.

Chapter three will describe the research design. It outlines research methodology, design and layout of the questionnaire, sample survey, sample size and data analysis.

Chapter four will describe in details the risk categories used to formulate the survey questionnaire.

Chapter five contains the main work of the thesis, which shows the results and discussion of the survey. Results are presented in five main parts: general background information of the respondents, risk allocation, risk importance, risk effects and finally the added risk categories. The results are presented in tables and figures and are analyzed.

Chapter six is the last chapter of the thesis and it presents the conclusions of the survey, the recommendations and the suggestions for further studies.

Finally, survey questionnaires, references used for the thesis, a list of construction contractors and calculations are located in the appendices of the thesis.

CHAPTER TWO

LITERATURE REVIEW

2.1 OVERVIEW

This chapter summarizes the comprehensive literature review of the available work reported on the subject of risk management in the construction industry, and the allocation and importance of risks.

2.1.1 Definition of Risk / Risk Management

The concept of risk can be applied to almost every decision-making action we take ranging from zero risk to full risk. For any decision we make, it should be based on three broad elements. These elements are:

- Certainty
- Risk
- Uncertainty

Certainty exists only when the decision –maker can specify exactly what will happen during the period of time covered by the decision. He is certain of the consequences and the outcome of that decision during that period of time. This type of confidence, of course, does not happen very often in a complex industry like construction industry.

Because risk is inevitable in almost every decision we make, different definitions are given to the word risk. Webster New Collegiate Dictionary defines the word risk as: " the possibility of loss or injury .... The chance of loss or the perils to the subject matter..." [29].

In other words, risk could be defined as a situation in which there is a lack of information / data or previous experience to that particular situation being considered by the decision-maker at that time.

While some authors and most people consider risk and uncertainty as two similar and synonymous terms, risk and uncertainty are two different terms meaning completely different issues. Flanagan, R. (1999) states "There is a general consensus that a decision is made under risk when a decision-maker can assess, either intuitively or rationally, the probability of a particular event occurring".

In this section, risk and risk management is defined from the construction point of view. The following are some of these definitions:

1. Erikson (1979) defines risk in construction as: "Exposure to possible economic loss or gain arising from involvement in the construction process."

2. Jaafari and Schub (1990) define risk as: "The presence of potential or actual construction that could stand in the way of project performance causing partial or complete failure

either during construction and commissioning or at the time of utilization".

3. Albahar and Crandall (1990) define risk as: "the exposure to the chance of occurrence of events adversely or favorably affecting project objectives as a consequence of uncertainty".

4. Kähkonen and Huovlla (1999) define systematic project risk management as "advanced preparation and decision making for minimizing the consequences of possible adverse future events and, on the contrary, to maximize the benefits of positive future events".

5. International Risk Management Institute, Inc. IRMI (1984 and 1995 supplement) defines risk management as "the process of identifying and analyzing risk, determining the most appropriate techniques for handling those risks, implementing the techniques, and monitoring the results. It differs from the old approach to managing these risks, frequently called insurance management, in that it recognizes that there are alternative techniques for handling these risks, that insurance is frequently the most expensive of all the available techniques, and that insurance should be used only as a last resort"

2.1.2 History of Risk Management In Construction

The topic of risk management has been important ever since the early age of humans on earth. In Covello and Mumpower's (1985) article, and according to Grier (1981), the first signs of risk management dated back as far as 3200BC in the Tigris-Euphrates valley with a group of people called the Asipu. One of their functions was to act as risk consultants. Their procedure would be to identify the important dimensions of the problem, propose alternative solutions, and collect data on the likely outcome. Their data sources were signs from Gods.

However, in my literature review I found that the actual term "risk analysis" first originated with Hertz (1964). He proposed simulation by utilizing the computer to derive the probability distribution of the rate of return of an investment project.

Risk management is not new, nor does it employ black box magical techniques. Traditionally it has been applied instinctively, with risks remaining implicit and managed by judgment, and informed by experience (Mills, 2001).

People tend to use their intuition, experience and judgment in making decisions in construction.

Zack (1996) states that, in the past, normal risks associated with construction contracts were primarily physical in nature. The risks of

underground conditions, availability and productivity of labor, the effect of weather, the ability to obtain materials and equipment, or other onsite problems that prevented work from proceeding were fairly well known and predictable. Both owners and contractors knew these risks.

According to Baker, Ponniah and Smith (1999), formal risk management in construction has become an integral process only in the past few decades. The reason for this is the rapid advancement of technology. Risk and the management of risk, therefore have become a specialized subject in itself.

2.1.3 Current Practice

Hayes *et al.*, (1986) state that the construction industry is one of the most dynamic, risky and challenging businesses. However, the industry has a very poor reputation for managing risk, with many major projects failing to meet deadlines and cost targets. This is influenced greatly by variations in weather, productivity of labor and plant, and quality of material. All too often, risks are either ignored, or dealt with in a completely arbitrary way: simply adding 10 per cent contingency onto the estimated cost of a project is typical.

According to Akintoye and MacLeod (1997), construction risk is generally perceived as events that influence project objectives of cost, time and quality. Analysis and management of risk in construction depend mainly on intuition, judgment and experience. Because of the lack of knowledge and doubt on the suitability of risk analysis procedures, formal and

systematic risk analysis and management procedures are rarely used in the construction industry.

Bing *et al.* (1999), state that a systematic approach to risk management is not a widely-spread practice in the construction industry due to the complex nature and involvements of this industry.

2.2 WHY RISK ASSESSMENT/SYSTEMATIC RISK MANAGEMENT IS NEEDED

To answer this question, we need to know the importance and benefits of systematic risk management in the construction industry.

According to Godfrey, (1996), the systematic risk management program helps to:

- Identify, assess, and rank risks, and make the risks explicit.
- Focus on the major risks of the project.
- Make informed decisions on the provision for adversity.
- Minimize potential damage should the worst happen.
- Control the uncertain aspects of construction projects.
- Clarify and formalize the company's role and the roles of others in the risk management processes.
- Identify the opportunities to enhance project performance.

Mills, (2001) states that systematic risk management is "expecting the unexpected- it is a tool which helps control risks in construction projects". And it has the following advantages:

- Questions the assumptions that most affect the success of your project;
- Concentrates attention on actions to best control risks;
- Assesses the cost benefit of such actions.

2.3 RISK MANAGEMENT PERCEPTIONS AND TRENDS IN CONSTRUCTION

2.3.1 *Importance of Risks and Risks Allocation*

Several studies have been conducted to identify the risk categories and to allocate the party/ies responsible for each category, whether it is the owner, contractor or shared between the two parties. Strassman and Wells (1988) have identified several risk factors associated with construction. From a client's perspective, these risks are:

1 Costs will escalate unpredictably
2 Structure will be faulty and need frequent repairs
3 The project will simply be abandoned and partially paid for but incomplete and useless.

Similarly, from a contractor's point of view the risk factors are:

1. Fears of inclement weather
2. Delays in site availability
3. Unforeseen subsoil conditions
4. Inadequate detail drawings
5. Late material deliveries
6. Unanticipated price changes
7. Faulty subcontracting
8. Unproductive labor and strikes

Another study by the American Society of Civil Engineers (ASCE) was made in 1979 to identify risk and the allocation of each risk category.

In a risk identification and allocation survey of the top 100 large USA construction contractors by Kangary, R. (1995), respondents were asked to identify the importance of risks associated with construction from the owner's and the contractor's perspective. Also, they were asked to place these risks into three allocations. Allocated to the owner, construction contractor, or shared between the two parties. The importance of risks to each party is shown in Table 2.1 and the allocations of risks are shown in Table 2.2.

A similar survey conducted by ASCE in 1979 showed that contractors were less willing to assume risks that are related to contractual and legal problems in the form of risk sharing with the owner.

Table 2. 1: Risk Importance

Level of importance	Risk Description
Most important	Safety
	Quality of work
	Defective design
	Labor and equipment productivity
	(tie) Contractor competence /delayed payment
Least important	Change in government regulations
	Acts of God
	Defective engineering
	(Tie) Permits and ordinances/ inflation

Source: Kangari (1995)

Table 2. 2: Risk Allocations

Risk allocation	Risk description
Contractor	Labor and equipment productivity
	Quality of work
	Labor, equipment, and material availability
	Safety
	Defective material
	Contractor competence
	Inflation
	Actual quantities of work
	Labor dispute
Owner	Differing site condition
	Defective design
	Site access/right of way
	Permits and ordinances
	Change in government regulations
	Delayed payment on contract
	Changes in work
Shared	Financial failure-any party
	Change-order negotiations
	Indemnification and hold harmless
	Contract-delay resolution
Undecided	Act of God
	Third-party delays
	Defective engineering

Source: Kangari (1995)

A similar study was conducted in Kuwait by Kartam (2001) to asses, allocate construction risks and to evaluate the importance of each risk category from the perspective of the construction contractor. Results of the study indicating the allocation and significance of each construction risk type are shown in Tables 2.3 and 2.4.

Table 2. 3: Risk Allocations and Significance

Types of risks	Risk allocation			Risk significance		
	Owner	Contractor	Shared	Not Significant	Significant	Very Significant
Permits & regulations	74%	12%	14%	10%	61%	29%
Scope of work definition	71%	16%	13%	29%	32%	39%
Site access	52%	22%	26%	16%	65%	19%
Labor, material& Equip. availability	0%	97%	3%	0%	19%	81%
Productivity of labor & equipment	0%	94%	6%	0%	32%	68%
Defective design	52%	16%	32%	0%	23%	77%
Changes in work	72%	10%	18%	13%	65%	22%
Differing site condition	21%	73%	6%	6%	84%	10%
Adverse weather conditions	6%	71%	23%	32%	68%	0%
Acts of God	15%	10%	75%	55%	26%	19%
Defective materials	0%	74%	26%	16%	58%	26%
Government acts	23%	35%	42%	19%	65%	54%
Accuracy of project program	3%	84%	13%	3%	45%	52%
Labor disputes	0%	96%	4%	42%	52%	6%
Accidents / Safety	0%	90%	10%	29%	65%	6%
Inflation	7%	70%	23%	23%	55%	22%
Contractor competence	16%	75%	9%	6%	19%	75%
Change order negotiations	21%	3%	76%	3%	87%	10%
Third party delays	16%	58%	26%	3%	19%	78%
Coordination with subcontractors	0%	94%	6%	3%	19%	78%
Delayed dispute resolutions	29%	16%	55%	6%	65%	29%
Delayed payment on contract	77%	9%	14%	0%	16%	84%
Quality of work	0%	85%	15%	6%	39%	55%
Financial failure	7%	21%	72%	0%	10%	90%
Actual quantities of work	18%	72%	10%	6%	39%	55%
War threats	26%	0%	74%	32%	26%	42%

Source: Kartam (2001)

Table 2. 4: Risk Allocations

Risk Allocation	Risk Description
Contractor	Labor, equipment, and material availability productivity
	Labor dispute
	Productivity of labor and equipment
	Coordination with subcontractors
	Accidents /Safety
	Quality of work
	Accuracy of project program
	Contractor competence
	Defective material
	Differing site conditions
	Actual quantities of work
	Adverse weather conditions
	Inflation
Owner	Delayed payment on contract
	Permits and regulations
	Changes in work
	Scope of work definition
Shared	Change-order negotiations
	Acts of God
	War threats
	Financial failure-any party
Undecided	Site access
	Defective design
	Government acts
	Third-party delays
	Delayed disputes resolution

Source: Kartam (2001)

2.3.2 Contingency / Risk Perspectives

Construction contractor contingency can be thought of as a contractor's estimate of the extraordinary risks or losses they will encounter in the project. These would be risks not covered by bonds, insurance or by the contract and they are uncertain. For examples, unforeseen conditions and unclear scope issues that the contractor cannot get enough information about at the time of bidding. Modern estimating textbooks usually represent the contractor's contingency as a fixed percentage of the direct cost. Generally the percentage reported is around 5-10 % of the contract value. This percentage is greatly affected by external factors such as the market, competitions and on-hand projects.

Smith, G. And Bohn, C., (1999) concluded from their investigation that contractors had no knowledge of formal modeling techniques published on risk models. Where contingency was included in contracts, the construction managers used a percentage of the total cost approach based on their intuition and previous contract knowledge.

Each party (owners, engineers and contractors) in a contractual relationship will perceive risks from their own perspective. For example, the owner, who is the ultimate beneficiary of the contract, may be considering the project from a production requirement perspective.

2.4 RISK CLASSIFICATIONS

Jaafari and Schub (1990) classify risks as technical risks and technological risks. Technical risks are those related to the fundamental properties, processes and concepts such as failure of an earth dam embankment in operation due to the overestimating of the shear strength of the structure.

Technological risks are those related to plant and manufacturing and construction processes, state of hardware and the like. Failure of a construction method to achieve its production level is an example of technological failure.

Al Bahar and Crrandal (1990) propose classification of risks that classifies the potential risks according to their nature and potential consequences. Their classification scheme is composed of six categories. They are:

(1) Acts of God
(2) Physical
(3) Financial and economics
(4) Political and environmental
(5) Design
(6) Construction related risks.

Farquharson J.A (2000) classifies risk assessment analysis as qualitative (i.e., what-if/ checklist analysis) and quantitative analysis. The qualitative analysis is often sufficient for making good decisions about the allocation

of resources for safety improvement which in turn results in reliability and cost saving. But project managers and contractors also "seek quantitative - direct- cost/ benefit information upon which to base their decisions, they increasingly turn their attention to the use of a more detailed analysis technique (quantitative risk assessment)".

For Farquharson, the process of risk analysis includes answering three questions:

1. What can go wrong?
2. How likely is it?
3. What are the impacts?

Also, he suggests using the process of risk assessment (Figure 2.1) to acquire the understanding, extent and the degree of risk analysis.

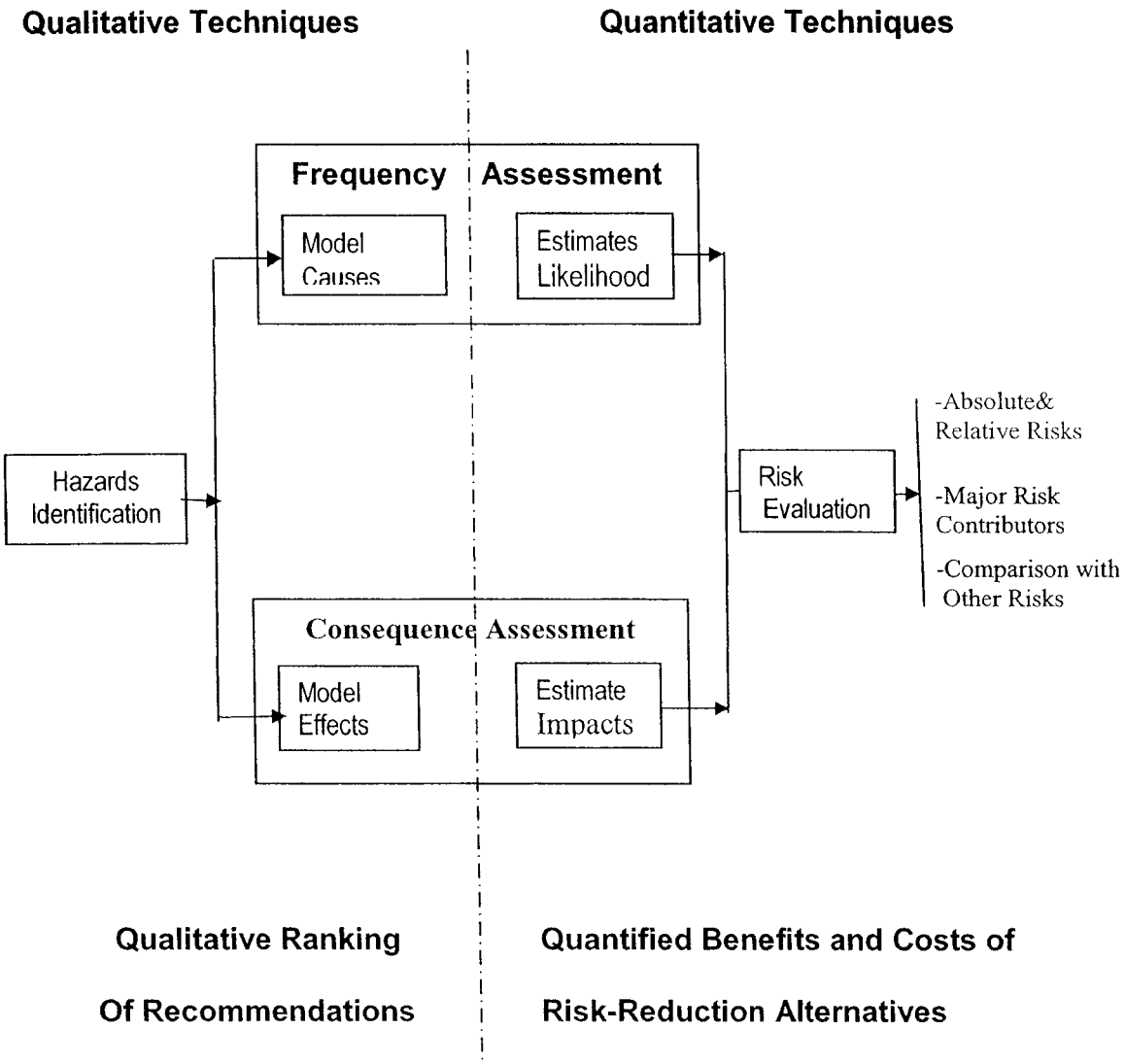

Figure 2. 1: The Process of Risk Assessment

Source: Farquharson (2000)

Assaf and Jannadi (1994) classify risk into two types pure and speculative risks. "There are two types of risk that contractors need to manage. These are pure and speculative risks. Speculative risks expose the risk taker to either profit or loss "

Flanagan,R.. (1999) suggests three ways of classifying risk "by identifying the consequence, type and impact of risk" as shown in Figure 2.2.

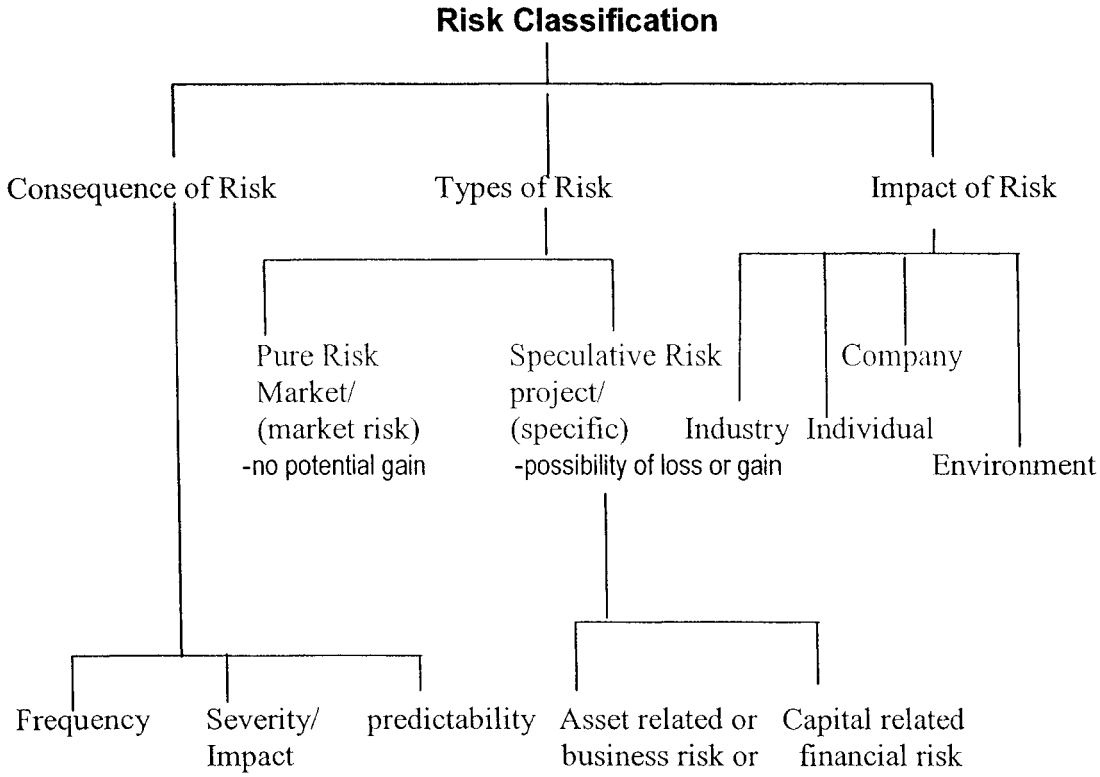

Figure 2. 2: Risk Classification

Source: Flanagan (1999)

2.5 RISK ANALYSIS AND RISK MANAGEMENT

In the construction industry, paying attention to risk is essential to ensure completing the project on time, on budget and with a good quality end product. Few people would deny the importance of assessing the risks in construction, but few analyze the risks systematically other than by using intuition and experience. The management of risks in the construction industry is a central issue for the success or failure of any project. Is it enough to be aware of risks or should we try to quantify them, analyze them and manage them?

Flanagan, R. (1999) defines a risk management program as " a system which aims to identify and quantify all risks to which the business or project is exposed so that a conscious decision can be taken on how to mange the risks". He added that the risk management system must be practical, realistic and must be cost effective.

Because of the complex nature of construction activities, processes, environment and organization, it involves high degree of risk. However, analysis and management of risk in the construction industry are not well developed. Almost all parties (designers, owners and contractors) involved in this industry approach risk analysis and management from individual intuition, judgment, and experience gained from previous contracts (Al-labtabi and Diekmann 1992).

Assaf (1982) proposes a systematic approach for the management of pure risk. It includes:

(1) Risk identification by either financial statements, flow chart, questionnaire and checklist; or a combination of them

(2) Analysis of risk treatment alternatives by either risk control, avoidance, retention or risk transfer

(3) Risk administration by either the contractor agency or an outside agency.

Perry and Haynes (1985) have suggested a simple and systematic approach for construction management, which consists of three stages:

(1) Risk identification
(2) Risk analysis
(3) Risk response.

Buchan (1994) proposes three steps, namely risk identification, analysis and response, and he implemented a 15-step sequence to account for risk management. He concludes that if these simple steps are followed then beneficial outcomes and a stable risk environment should be obtained. Bostwick (1987) adds a fourth step; risk response; to the above three steps.

Nummedal *et al.* (1996), Eloff *et al.* (1993) and the British Standards BS 8444 (BSI, 1996) propose five steps to manage risks. These systematic five steps used for a comprehensive risk management procedure are:

(1) Risk Identification

(2) Risk Estimation

(3) Risk Evaluation

(4) Risk Response

(5) Risk Monitoring

Baker *et. al* (1999) have suggested fitting these five steps in a simple circular procedure which, if maintained, will yield a controlled risk environment. The first two steps, namely risk identification and risk estimation, can come under the broader title of risk analysis. Risk analysis with risk evaluation can be grouped under risk assessment, with response and monitoring collectively entitled risk control as shown in Figure 2.3.

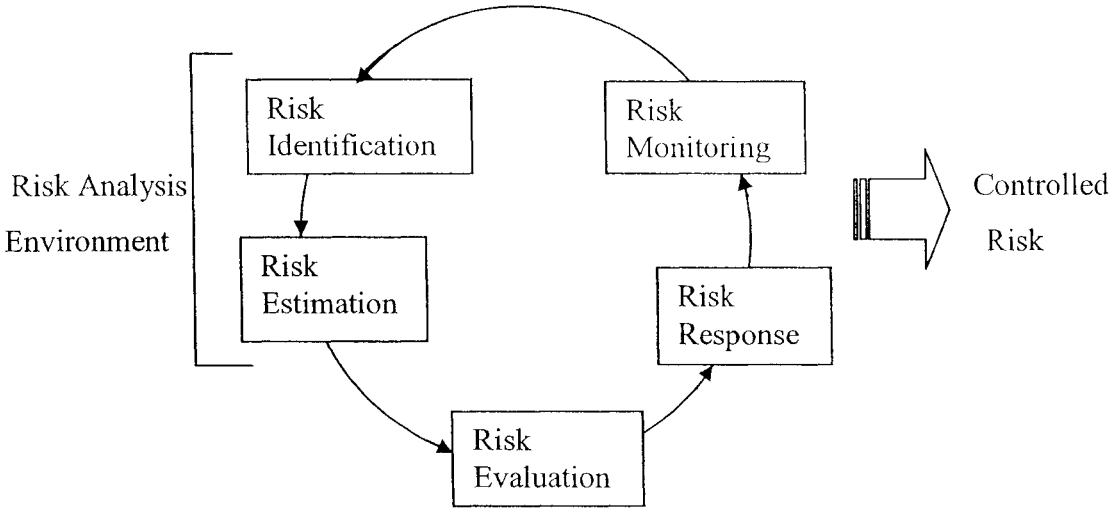

Figure 2. 3: Systematic Risk Management Steps

Source: Baker (1999)

Kähkönen, K & Huovila, P. (2000) pointe out that systematic project risk management includes five phases as shown in Figure 2.4. They recommend a continuous process of risk identification, risk analysis and continuous evaluation, control and accumulation of experience through out the process

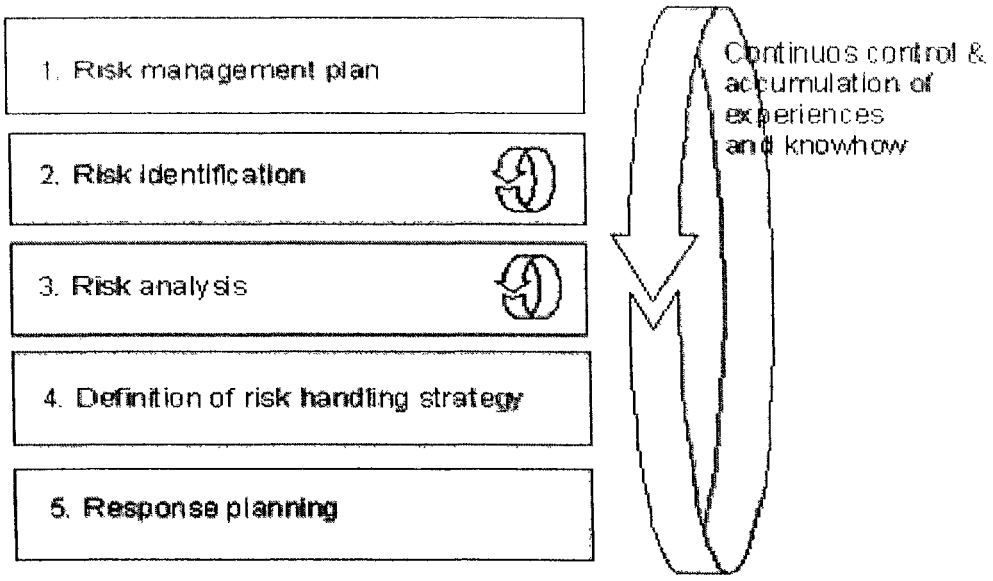

Figure 2. 4: Systematic Project Risk Management

Source: Kähkönen (2000)

They state "Systematic project risk management means advanced preparation and decision making for minimizing the consequences of possible adverse future events and, on the contrary, to maximize the benefits of positive future events".

According to this definition, project risk management is more related to 'planning' rather than 'management', which usually refers to on-line

control of events. However, it is widely accepted that project risk management must be seen as a pro-active technique to identify potential risks, analyze them, do response planning and make necessary decisions.

Risk analysis is an integral part of the risk management system or program. It gives an insight into what happens if the project does not proceed according to plan. There are many theories that can be utilized to analyze risks including a decision tree, decision tables, utility theory, game theory, simulations and an AHP model. But, no matter how good the analytical techniques, it is the application and interpretations of results by the professional that determines the success of the system.

Ibbs and Crandall (1982) developed their risk decision model based on utility theory. Utility theory models are useful for modeling human value systems into a mathematical formulation. This decision modeling approach allows contractors to estimate the impact of their risk decision based on Bayesian probability analysis.

Smith (1999) uses a Monte Carlo simulation to generate the project cost cumulative density function. The construction Industry Institute's (1989) publication *on Management of Project Risks and Uncertainties* also describes a Monte Carlo technique to evaluate risks.

Fuzzy mathematics has been used to estimate risk probabilities, which are difficult to measure using the traditional mathematics. Risks in construction are often discussed using terms such as good or bad and high and low. Fuzzy sets provide a convenient way to include a measurement of these

types of variables. Boyer and Kangari (1989) suggest using fuzzy set theory in an expert system environment to evaluate risk based on perceived severity and sensitivity to project changes.

Flanagan, R. (1999) suggests that clear thoughts should be applied to the best available data in a structured and systematic way to analyze risks in a project. Figure 2.5 identifies the systematic approach.

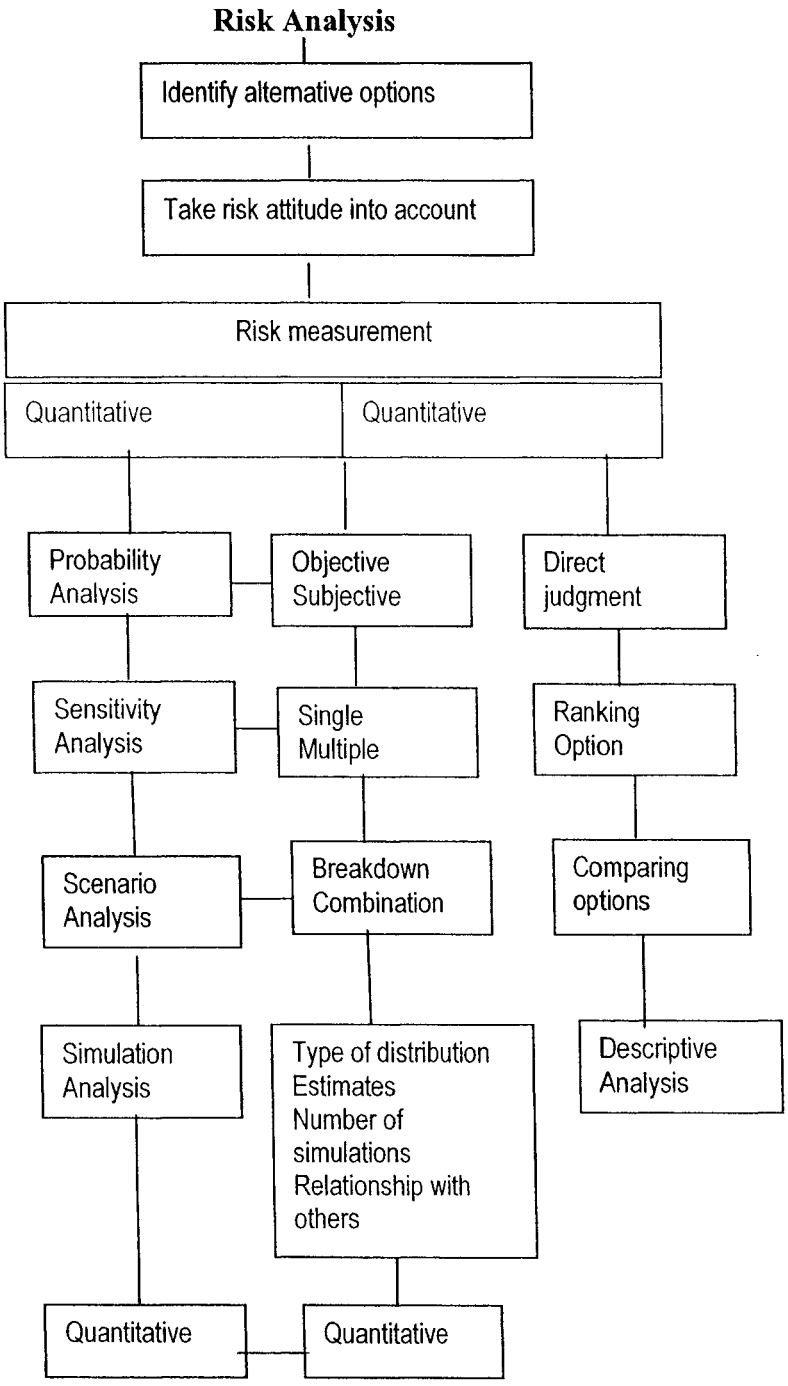

Figure 2. 5: Risk Analysis Approach

Flanagan (1999)

2.6 RISK RESPONSE

Pundist has argued that there are four ways to deal with risk in the construction industry:

1- "*The umbrella approach*" where you account for every possible eventuality by adding a large premium to the price. This will increase the bidding price and eventually lead to few contracts.

2- "*The Ostrich approach*" where you bury your head in the sand and assume everything will be alright, and that somehow you will manage.

3- "The *intuitive approach*" where you only depend on intuition and gut feeling, ignoring any formal analysis.

4- "The *brute force approach*" where you focus on the uncontrollable risks and say that you can force them to be controlled, which of course they cannot be.

Responses to risks in construction can take any of the four approaches: risk retention, risk reduction, risk transfer and risk elimination/ avoidance (Raftery, 1997).

2.6.1 Risk Retention

Risk retention is sometimes called risk absorption. Not all risks can be transferred, but even if they can be transferred it may be more economical to retain them. Risks that produce small and repetitive losses that can be best controlled should be retained.

2.6.2 Risk Reduction

Risk reduction is sometimes called risk control. It may be argued that reducing risks is a part of risk retention because the risks have to be retained before they can be reduced (Baker, Ponniah and Smith, 1999). Usually risks related to safety can be reduced. Reduction falls into three basic categories:

First, is the education and training programs that alert the staff to potential risks within the working environment. Loss prevention programs and safety alerts and training play major roles in preventing accidents and consequently reduce risks.

Second, is the physical protection of people and equipments. Continuous maintenance and updating of equipment and tools help prevent damages and losses and in turns reduce risks.

Third, is the consistent company's systems and procedures. Clear procedures, good housekeeping, first aid and security procedures can lead to a better working environment, improved labor relations and increased productivity which in turn reduce risks.

2.6.3 *Risk Transfer*

Transferring risk does not reduce the severity of the source of risk. It only shifts the risk to another party to deal with it. In some cases, risk transfer can significantly increase risk because sometimes the party to whom it is being transferred may not be capable of handling the risk. For example, a general contractor might transfer risk to an incompetent sub contractor who can not handle the risk and this ends up in a more risky situation.

Risk transfer can be in two ways (Thompson and Perry, 1992) : (a) the property or activity responsible for the risk may be transferred to a sub contractor; or (b) may be retained, but the financial risk transferred through insurance.

2.6.4 *Risk Avoidance*

Risk avoidance is sometimes called risk elimination. A contractor not bidding on a project or an owner deciding not to proceed with the project are simple examples of risk avoidance.

There are other ways of eliminating risks like pre-contract negotiation or including exemption clauses in the contract, either to avoid risks or to avoid consequences of certain risks.

CHAPTER THREE

RESEARCH DESIGN

3.1 INTRODUCTION

This section clarifies the selected strategies for conducting the research, the type of data required and the techniques for collecting the data.

3.2 RESEARCH METHODOLOGY

The research methodology will include the following essential six steps:

Step one: A comprehensive literature review of the available work reported on risk management in construction industries, allocation of risks and the importance of these risks. The review includes the recent literature on the subject that includes the past ten years.

Step two: Definition of important risk parameters and categories related to risk allocation, risk importance and effects of risks on typical projects.

Step three: Design of a questionnaire related to the allocation of risks, importance and effects of these risks on the construction industry and the local construction contractors. The questionnaire was mailed and E-mailed to the local construction contractors.

Step four: Data was collected and compiled.

Step five: Collected data was analyzed.

Step six: Results from the analyzed data were summarized and presented.

Step seven: Conclusion of the research, recommendations and suggestions for further studies were incorporated.

3.3 DESIGN OF QUESTIONNAIRE

The questionnaire contains 31 short and straight-forward questions, and is designed in such a way that completing it should not take more than 25-30 minutes considering the busy schedule of project managers/ project engineers completing the survey questionnaire.

The questionnaire includes two sections. The first section will provide general information about the construction contractor like the size of the firm, how long the firm has been in business and background information about the individual completing the questionnaire.

The second section includes the main questions about the assessment of construction risks. It starts with a brief description to help the applicants better understand the components of each question before answering this part of the questionnaire. The responses to each question

are divided into four groups: risk allocation (both perception and common practice), risk importance and effect of that risk on the project.

In this survey, questions related to the allocation and importance of risks are similar to the questions Kartam (2001) used for the survey of risk and its management in the Kuwaiti construction industry. Kartam used 26 risk categories in his survey; 21 of them are similar to those used by Kangari (1995). In this survey, 25 risk categories will be used for risk assessments focusing on risk allocation, risk importance and risk effect on the project. Effect of these risk categories on the project were not surveyed neither by Kangari's nor by Kartam's questionnaires. Similarly, a comparison between contractor perception and common practice of allocation construction risks was not done in the previous studies.

At the end of the questionnaire the chance is given to the contractor to add and rate any additional risk category that he might think has any significance for future similar studies.

Finally, full contact information of the surveyors is included at the end of the questionnaire for the applicants if they need any clarification or if they have any questions regarding the study.

Layout of the Questionnaire

The layout of the questionnaire is shown in Fig. 3.1.

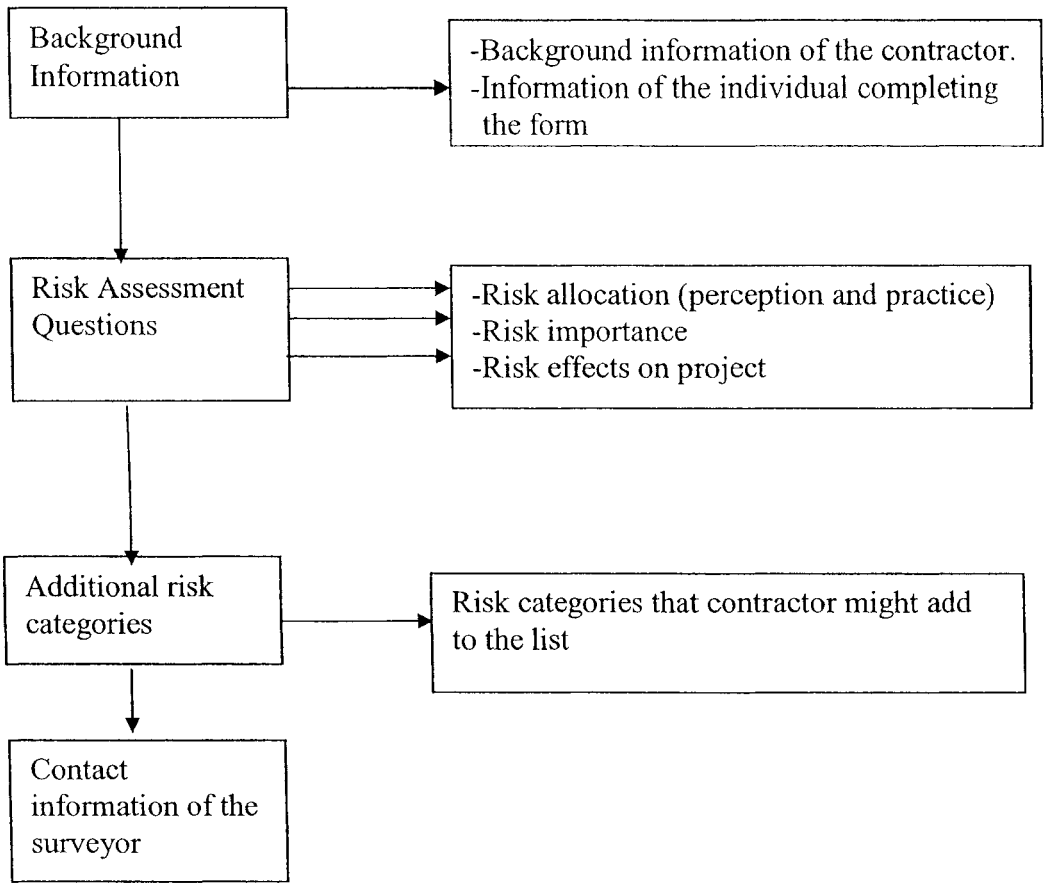

Figure 3. 1: Layout of Questionnaire

3.4 SAMPLE SURVEY

Selection of the sample for the survey from the big list of contractors in the construction industry plays a major role in making the research more effective and representative. By carefully considering the research theme from different angles and to avoid any possible conflict and discrepancies in the collected data, only construction contractors were selected. The sample survey was selected from the list obtained from the Chamber of Commerce, Eastern Province Chapter. Only medium to large construction contractors working in the Eastern Province of Saudi Arabia (Grades 1 or higher) per the classification of the Chamber of Commerce were included in the survey.

3.5 SAMPLE SIZE

The sample size that would represent the population for the survey was calculated based on the following formula (Kish, 1995)

$$n_\circ = (p*q)/ v^2 \quad \text{---------- (1)}$$

$$n = n_\circ / [1 + (n_\circ / N)] \quad \text{---------- (2)}$$

Where:

$n_\circ$ = First estimate of sample size

p =The proportion of the characteristic being measured in the target population

q = 1-p

v = The maximum percentage of standard error allowed

N = The population size

n = The sample size

For the purpose of getting the maximum sample size, the values of (p) and (q) were taken as 0.5 for both. The maximum standard error allowed (v) in this study was taken as 10%. The total population considered from the list obtained from the Chamber of Commerce, Eastern Province consisted of 82 construction contractors (Appendix II)

Applying the above formula, the sample size is:

$n_o = (0.5 * 0.5)/ (0.1)^2 = 25$

$n = 25/ [1 + (25/82)] = 19.2$

The minimum required response rate was (19.2/82) * 100 = 23.4 %. However the actual response rate was (28/82) * 100 = 34.15, which exceeded the minimum requirements.

3.6 DATA ANALYSIS

Data gathered from the questionnaire is analyzed and used to identify the respondents' allocation and importance of each type of risk categories and the effect of each risk on the project. The analyzed data is presented in a tabulated format and figures. Allocation of risks as practiced in construction industry in the area is compared with the perception of local construction contractors for allocating the same risks.

By carefully studying the results of the survey, a better understanding will be gained of the current situation in the construction industry from a local contractor's point of view. This also allows recommending the next approach for further studies of the subject.

3.7 SCORING

The main section of the questionnaire on the importance of risk categories basically uses an ordinal scale. This ordinal scale does not offer in its qualitative 3 points scale, namely very important, important and less important, a direct quantitative comparison between its intervals. This scale will be transformed into an interval scale by assigning a weight to each interval as indicated in the questionnaire. This transformation will facilitate the required parametric statistics. No scoring is needed for other sections of the questionnaire. Scoring will be as follows:

- "Very important" equals 5 points
- "Important" equals 3 points
- "Less Important" equals 1 point

Importance Index of each risk category will be calculated as follows:

$II_{R1} = 5x1 + 3x2 + 1x3 / (x1 + x2 + x)$

Where:

II_{R1}: importance Index (R1 denotes risk category 1 in this case)

X1: Number of respondents answering very important

X2: Number of respondents answering important

X3: Number of respondents answering less important

Microsoft Excel is used as software to perform weighting, ranking and to calculate the percentage of each risk category. Printouts of Excel tables are in Appendix V.

Frequencies and ratio calculation will be used for other sections of the questionnaire.

Frequency (%) = $n / N_T * 100$

Where:

n = number of respondents (frequency)

N_T = Total respondents

CHAPTER FOUR

RISK CATEGORIES ALLOCATION, IMPORTANCE AND EFFECTS

In this chapter the risk categories used to formulate the survey questionnaire is explained and detailed. Basically, three areas are investigated by this survey.

First, risk allocation (both from the Saudi contractors' point of view and as practiced) to either the owner, the contractor or shared by the two parties.

Second, the importance of each risk category to the contractor and the construction project.

Third, the effect of each risk category on the construction project (mainly on the budget, schedule, safety, and the quality of the project).

4.1 RISK CATEGORIES

Twenty five important risk categories were selected to compose the survey questionnaire. They have either direct or indirect effect on the project budget, schedule, safety and quality of the project and need to be carefully looked at in the assessments of risks management of construction projects. These categories are:

1. Permits and Regulations

For every construction project there are some local, national and international laws and regulations that govern the different aspects of that project. These regulations might include obtaining construction permits from the local municipality or the local authority and policies that control the development of the area such as safety and environmental regulations. Or could be any permits and regulations that control the interface of the construction project with other projects or agencies specially government and public properties.

Other examples of regulations are obtaining permits for utility (telephone, water and sewage) and power connections to the project site either during construction or after completion of the project.

2. Site Access

This risk category refers to the right of way and access to the project site. This is an important category especially if the project is in a remote or undeveloped area, or where access is limited to small trucks where large construction tools like big trucks and loaders cannot get into the project site. Also, this is important when the project is located in a very congested area or access to other facilities and public areas need to be blocked or detoured in some stages of the project.

3. *Scope Limitation And Work Definition*

Scope limits might not be clearly outlined and the work might not be well defined depending on the nature of the contract but this happens more in complex projects where all phases and systems of the project are virtually interconnected. This risk category becomes even more important when there are subcontractors or multiple contractors for the different phases of the project.

4. *Labor, Material And Equipment Availability*

This risk category is mainly related to the availability of some of the resources namely, labor, material and equipment. Certain jobs may require specific skilled expertise and /or special material and equipment that might not be available or scarce in the local market and take a long time to procure. For example a skilled qualified welder or special lifting and fitting of some heavy structure that may require crane capacity or piece of equipment that is not available in the local market may force the contractor to hire certain skilled labor and import the special piece of equipment or change the construction method to suit. This is more likely to happen in complex major projects or projects involving some degree of high technological complexity like the control system of process plants or construction of certain buildings like hospitals.

5. Labor And Equipment Productivity

Like the previous risk category, certain jobs involving the productivity of labors and equipment might be affected because of the complexity of the job or the nature of the work. If this is not routine, then the labor and/or the equipment operator need to go through a learning curve. Another example that might affect labor and equipment productivity is the morale of the labor and the use of defective tools and equipment.

6. Defective Design

It is impractical to make a 100% error free design especially in major and complex construction projects. Quite often, among the various project documents like drawings, scope of work, specification sheets and other project documents, one can find a detailed missed referenced, a note deleted or an incomplete specification sheet. This is more likely to happen if the design was not thoroughly reviewed or in fast track projects where design and construction are concurrent or construction even starts before the design is finalized. This will be a major risk category if the defect is significant and requires major modifications and re-working especially in a lump sum type of contract.

7. Changes In Work

A change in work is an important risk category in construction projects. It could be change in work procedures, methodology or change of plans and scope of work. These changes might lead to change orders,

demolitions and re-working and must be considered in the assessments of risks because they affect the project budget, schedule, safety and quality.

Normally changes in work result because of insufficient planning at the project definition stage or because of lack of clear scope and drawing details or simply because the owner's desire to make changes to the project.

8. *Differing Site Condition*

This is a clear risk category and could happen in most of construction projects. For instance the soil condition changes and the contractor might face rock or hard soil during excavation instead of soft soil as the top layer at the site showed or as the tender document may have indicated. Another example is underground buried utility piping, power cables and high water table area. These types of differing site conditions occur mostly in renovation and/or expansion of existing projects where new construction interface with the existing structures. These differing site conditions will require extra efforts and may necessitate special equipment and tools for excavation and/ or de-watering.

9. *Adverse weather conditions*

This risk category is an example of force majuere conditions. The contractor might be forced to alter his work schedule due to adverse weather conditions such as high temperature, high humidity, flood or high

wind. Saudi Arabia is known for high temperature and humidity as discussed in chapter one.

10. Acts of God

This category is similar to the previous one and is an example of force majure conditions too. They include things that could happen beyond the control of human and might affect the construction projects like hurricanes, earthquakes, volcanic rupture and other natural phenomena.

11. Defective material

Material is an essential resource for construction projects and there is a need for quality control and quality assurance to eliminate material replacement and re-work. This is an important risk category especially in the Saudi Arabian market where material standardization is not common and the local market is full of all kinds of material grades including sub-standard materials. This risk category becomes more important for lump sum and lump sum turn key contracts if the specifications were not well defined.

12. Changes in government regulations

Local authorities and government have specific codes and regulations that might be changed or revised from time to time. These regulations must be adhered to by contractors and owners of construction projects. For construction, design and environmental codes, normally designers

comply with these codes. However, new regulations may be issued between design and construction phases or after project bidding and may force some changes to the original scope and plans. Another example of government regulations is the regulation that controls labor and workforce recruitments. This is an important issue where the majority of construction workers in Saudi Arabia are foreigners. Also, these regulations might include changes in visa regulation or the restriction of some country's nationals from working in Saudi Arabia.

13. Labor dispute

This is more likely to happen in large companies where the work forces are multinationals who come from different countries with different backgrounds or where the relationships between management and workforce are tense. Since there are no labor or professional unions in Saudi Arabia, labor does not go on organized strike. Usually, any labor dispute is either resolved internally or by the local authorities and police.

14. Safety / Accidents

Safety and accidents in construction projects can not be overlooked, especially when the project involves deep excavation or high elevation construction. This risk category is inherited in the construction industry but can be minimized by following safety rules and the use of safety equipment such as goggles, safety hats and shoes. Another way of mitigation is by insurance.

15. Inflation

This risk category mainly depends on the economic conditions of the country. As the inflation rate increases, this risk becomes more important. Currently, the inflation rate in Saudi Arabia is low, so this risk category is low too but must not to be overlooked in the assessments of risk management in construction projects.

16. Contractor competence

This risk category is mainly related to the capability, skills, experience and proficiency of the contractor's organization including management and labor. This is important in performing major and complex construction projects.

17. Change-order negotiations

Changes to original plans, scope and specification are inevitable in most construction projects. Theses changes need initiation and negotiation of change orders for the deviation from original plans. Change orders are the most undesirable risk category to deal with if not negotiated and managed properly and are generally un-welcomed by all parties.

18. Third party delays

Examples of third party are subcontractors, material suppliers and other agency like the transportation or customs for imported materials. Other examples could be utility and power companies for utility connections and power supply to the construction project. Testing agency for soil or concrete testing and an inspection agency are another examples of third parties too if these agencies are not within the construction contractor's organization.

Delays from these parties could affect the schedule and consequently the budget of the project and they need to be carefully considered in the assessments risk management programs for construction projects.

19. Coordination with subcontractors

Coordination with subcontractors and material suppliers is an important task especially in a multi-player environment like big construction projects and could be risky if not kept smooth, in a timely manner and continuous. Miss-coordination between subcontractors and material suppliers (especially for long lead items) will lead to schedule and budget overruns.

20. Delayed dispute resolution

This risk category is an important one especially if the dispute is major and deferred without resolution. Disputes could be between the owner and the contractor, owner and material supplier, main contractor and

subcontractors or could be internally within each party organization. Disputes should be resolved immediately to eliminate any future consequences.

21. Delayed payment on contract

Payments on time are considered extremely important by contractors to maintain the cash flow and eliminate financial difficulties. Delayed payments will influence the financial situation of the contractor, especially if the due payment is substantial and/or delayed for long time.

22. Quality of work

Quality of work would reflect the reputation of the contractor and might either rank him on the top of contractors or force him out of the market. Generally, owners strive to get a quality end product by their project and contractors try their best to deliver quality projects. However, poor workmanship that leads to demolition and rework will negatively impact the project budget and schedule. Also, inferior quality of work will reflect the bad reputation of the contractor.

Good Quality control and quality assurance programs will help reduce the negative effects of this risk category.

23. Financial failure

Financial failure of any party (contractor or owner) will significantly impact the project schedule and consequently the budget. This is more likely to happen in big projects where the owner might not have sufficient fund for the project or if the contractor bids low on the project. Frequently, in Saudi Arabia some new contractors to the construction market face financial difficulties in executing large projects and eventually file for bankruptcy.

24. Actual quantities of work

This is more likely to happen in lump sum contracts if the scope of work is not well defined but this risk category has less effect in unit rate contracts. Also, this could be a major risk category if the scope of work is not well defined and the actual quantities can not be measured. Actual quantities of work are important for progress reports and payments.

25. Accuracy of project program

This risk category mainly deals with the project program of the construction project.

Like the appropriate contracting strategy for example lump sum, cost plus, lump sum turn key, design- build and operate or any other form of contract strategies and reasonable schedule to deliver the project. Also, it includes the financial, management and engineering program for the project.

4.2 RISK IMPORTANCE

Although risk importance varies from one project to another depending on the nature of the construction project, owner, contractor, type of contractual agreement and other factors, the questionnaire will elicit a general assessment of the importance of each risk category from the Saudi contactors' viewpoints and the general practice in the Eastern Province of Saudi Arabia.

4.3 RISK EFFECTS

All of the above risk categories will have potential effects on one or more of the project parameters namely budget, schedule, safety and quality. If these risks are not correctly assessed and managed, they will greatly impact the construction project.

CHAPTER FIVE
RESULTS DISCUSSION

5.1 INTRODUCTION

In this chapter, the results of the questionnaire are discussed, summarized and presented in tabulated format as well as in charts.

5.2 DIFFICULTIES ENCOUNTERED

There were some problems encountered during the survey. The first problem was the low response rate. Second, was the slow delivery of the questionnaire to the contractors. Initially the questionnaire was sent to the contractors using the local snail mail service on March 1st, 2003 but it took 16 days to reach some of the contractors. Third, e-mails of the contractors were not available. Fourth, since the questionnaire consisted of ten pages, it was difficult to fax to the contractors.

5.3 RESPONSE RATE

At the start, the contractors were contacted by telephone to ensure they are in the construction industry and were interested to participate in the research. Then the questionnaire was sent to a total of 82 contractors by snail mail. The response rate was very low and only 2 responded even after a follow up phone calls. The e-mails of the 82 contractors were obtained through the Chamber of Commerce Eastern Province Branch

and were confirmed by phone calls. The questionnaire was e-mailed to those contractors and followed up after 3 days by phone calls. The response rate of the emails was good and a total of 28 responded at this time.

The questionnaire was sent to a total of 82 contractors using both snail mail and email. A total of 30 replied in both. One contractor apologized and did not complete the questionnaire because the top management did not want to participate in the research. Also, another contractor did not complete the questionnaire and was dropped. So, only 28 of the total replies were considered in this study that makes the response rate of 34.15. The list of contractors is attached in appendix II.

5.4 DESCRIPTION OF RESULTS

The results are presented in five main parts. The **first** part discusses the general background information of the respondents. The results of this section were obtained from the answers of section "A" of the questionnaire.

The answers of section "B" of the questionnaire are discussed in the second, third and the fourth parts.

The **second** part discusses risk allocation to each party; namely contractor, owner or shared. Allocation of risks from the viewpoint of the respondents (contractors) and the common practice of allocating these risks are discussed and compared in this section.

The **third** part covers the importance of these risks.

The **fourth** part talks about the effect of these risks on the project from different angles like budget, schedule, safety and quality.

The **fifth** part outlines the answers to section "C" of the questionnaire.

5.4.1 Part 1: General Background Information

This section presents the general background information of the respondents to the questionnaire like company size, experience and individual completing the questionnaire. Respondents were spread all over the Eastern Province of the kingdom.

It was found that only 7.1% of the respondents, as a company, have less than 150 employees, and 92.9% have more than 150 employees. Regarding experience, most of them have been in the construction business for long time. Only 14.3% of the respondents have less than 10 years of experience; and 85.7% of them have experience of more than 10 years in the construction industry. This is shown in tables 5.1 and 5.2 respectively.

Since it was requested in the questionnaire that it is highly recommended that a project manager or a project engineer completes the questionnaire for better results, it was found that all the questionnaires were completed either by a project manager or a project engineer.

Table 5. 1: Number of Employees

Number of Employees	Number of respondents (Frequency)	Percent (%)
10 – 50	0	0
51 – 100	0	0
101 – 150	2	7.1
More than 150	26	92.9
Total respondents (N)	28	100

Table 5. 2: Experience of Respondents

Experience (years)	Number of respondents (Frequency)	Percent (%)
1 – 5	0	0
6 – 10	4	14.3
More than 10	24	85.7
Total Respondents	28	100

5.4.2 Part 2: Risk Allocation

This part represents the allocation of risk categories included in the questionnaire. There are 25 risk categories listed in section "B" of the questionnaire and the respondents were asked to best allocate these risks based on their perception to either the contractor, owner or shared between the two parties. For the same risk categories, the respondents were asked to allocate them based on the common practice in the area.

Tables 5.3 and 5.4 show the surveyed risks allocation from the contractors' opinion (perception) and as practiced, respectively. Table 5.3 lists the frequencies of the respondents in allocating each risk category as viewed by respondents (contractors). Based on the respondents' perception, two of the surveyed risks, namely labor and equipment productivity and labor disputes, are 100 % allocated to contractors. For site access, equal numbers of the respondents allocate this risk category to the owner, contractor and shared equally. In other words, 33% of the respondents allocate this risk to the owner, 33% of respondents allocate it to contractor, and 33% of the respondents think this risk should be shared. Table 5.3 also shows that 0% of the respondents (contractors) do not want any of the following risk categories to be allocated to them:

1. Defective design
2. Acts of God
3. Changes in government regulations
4. Change order negotiation

Table 5.4 shows the frequencies of the respondents in allocating each risk category as practiced in the construction industry in Saudi Arabia. It shows that six risk categories are fully allocated to contractors. These risk categories are:

1. Labor, material and equipment availability
2. Labor, material and equipment productivity
3. Labor disputes
4. Safety / accidents
5. Coordination with subcontractors
6. Accuracy of project program

This is a logical and anticipated result since the above categories are more under the control of contractors.

Table 5.5 shows the frequencies of respondents in allocating the surveyed risks as practiced verses the respondent's perception for easy comparison and evaluation. From Table 5.5 we can see that there are two risk categories:

Labor and equipment productivity and labor disputes, are consistently and fully allocated to the contractor (both in practice and in the contractor's opinion).

Also, from the same table we can see that no respondent allocated the following risk categories to the owner (both in practice and perception):

1. Safety / accidents
2. Coordination with subcontractors
3. Delayed dispute resolution
4. Quality of work.

Table 5. 3: Allocation from Contractor's Opinion (Perception)

Risks Description	Risk Allocation (CONTRACTOR'S OPINION)		
	Owner	Contractor	Shared
Permits & regulations	44%	33%	22%
Site access	33%	33%	33%
Scope limitation & work definition	67%	11%	22%
Labor, material& Equip. availability	11%	89%	0%
Labor & equipment Productivity	0%	100%	0%
Defective design	56%	0%	44%
Changes in work	67%	22%	11%
Differing site condition	33%	44%	22%
Adverse weather conditions	11%	22%	67%
Acts of God	22%	0%	78%
Defective materials	11%	67%	22%
Changes in government regulations	44%	0%	56%
Labor disputes	0%	100%	0%
Safety/ Accidents	0%	67%	33%
Inflation	33%	11%	56%
Contractor competence	22%	56%	22%
Change order negotiations	11%	0%	89%
Third party delays	33%	22%	44%
Coordination with subcontractors	0%	78%	22%
Delayed dispute resolutions	0%	11%	89%
Delayed payment on contract	78%	22%	0%
Quality of work	0%	63%	38%
Financial failure	56%	11%	33%
Actual quantities of work	22%	33%	44%
Accuracy of project program	11%	33%	56%

Table 5. 4: Risk Allocation (Practice)

Risk Description	Risk Allocation(practice)		
	Owner	Contractor	Shared
Permits & regulations	33%	56%	11%
Site access	0%	89%	11%
Scope limitation & work definition	22%	56%	22%
Labor, material& Equip. availability	0%	100%	0%
Labor & equipment Productivity	0%	100%	0%
Defective design	0%	44%	56%
Changes in work	22%	44%	33%
Differing site condition	0%	78%	22%
Adverse weather conditions	0%	89%	11%
Acts of God	11%	22%	67%
Defective materials	11%	89%	0%
Changes in government regulations	11%	67%	22%
Labor disputes	0%	100%	0%
Safety/ Accidents	0%	100%	0%
Inflation	11%	67%	22%
Contractor competence	0%	78%	22%
Change order negotiations	0%	44%	56%
Third party delays	0%	78%	22%
Coordination with subcontractors	0%	100%	0%
Delayed dispute resolutions	0%	67%	33%
Delayed payment on contract	33%	44%	22%
Quality of work	0%	89%	11%
Financial failure	0%	33%	67%
Actual quantities of work	0%	78%	22%
Accuracy of project program	0%	100%	0%

Table 5. 5: Risk Allocation Practice Vs. Perception

Risk Description	Risk Allocation (practice)			Risk Allocation (contractor's opinion)		
	Owner	Contractor	Shared	Owner	Contractor	Shared
Permits & regulations	33%	56%	11%	44%	33%	22%
Site access	0%	89%	11%	33%	33%	33%
Scope limitation & work definition	22%	56%	22%	67%	11%	22%
Labor, material& Equip. availability	0%	100%	0%	11%	89%	0%
Labor & equipment Productivity	0%	100%	0%	0%	100%	0%
Defective design	0%	44%	56%	56%	0%	44%
Changes in work	22%	44%	33%	67%	22%	11%
Differing site condition	0%	78%	22%	33%	44%	22%
Adverse weather conditions	0%	89%	11%	11%	22%	67%
Acts of God	11%	22%	67%	22%	0%	78%
Defective materials	11%	89%	0%	11%	67%	22%
Changes in government regulations	11%	67%	22%	44%	0%	56%
Labor disputes	0%	100%	0%	0%	100%	0%
Safety/ Accidents	0%	100%	0%	0%	67%	33%
Inflation	11%	67%	22%	33%	11%	56%
Contractor competence	0%	78%	22%	22%	56%	22%
Change order negotiations	0%	44%	56%	11%	0%	89%
Third party delays	0%	78%	22%	33%	22%	44%
Coordination with subcontractors	0%	100%	0%	0%	78%	22%
Delayed dispute resolutions	0%	67%	33%	0%	11%	89%
Delayed payment on contract	33%	44%	22%	78%	22%	0%
Quality of work	0%	89%	11%	0%	63%	38%
Financial failure	0%	33%	67%	56%	11%	33%
Actual quantities of work	0%	78%	22%	22%	33%	44%
Accuracy of Project Program	0%	100%	0%	11%	33%	56%

The respondents' frequencies of risk allocation, both from contractor's perception and practice, shown in Tables 5.3 and 5.4 respectively, will be appropriately allocated to each party (namely, contractor, owner or shared) if the frequency is more than 60%. In other words, for a risk category to be fully appropriated, an allocation method, it requires at least a 60% response rate. If a risk category receives less than a 60% response rate for any party, it will be considered as an undecided allocation.

In previous similar studies done by Kangary, R. (1995) in USA and by Kartam (2001) in Kuwait, they both assumed a response rate of 70% for a risk category to be fully appropriately allocated. I think a response rate of 70% is high to be considered as a majority. For this study, a 65% response rate is assumed for a risk category to be fully allocated to a construction party.

Table 5.5 shows the risk allocation from the contactors' perception after applying the 65% response rate criteria. Similarly, Table 5.6 shows the risk allocation as practiced in the construction industry in Saudi Arabia.

Table 5. 6: Allocation from Contractor's Opinion (Perception)

Risk Allocation	Risk Description
Contractor	Labor & equipment Productivity
	Labor disputes
	Labor, material& Equip. availability
	Coordination with subcontractors
	Safety/ Accidents
	Defective materials
Owner	Delayed payment on contract
	Changes in work
	Scope limitation & work definition
Shared	Change order negotiations
	Delayed dispute resolutions
	Acts of God
	Adverse weather conditions
Undecided	Quality of work
	Permits & regulations
	Site access
	Defective design
	Changes in government regulations
	Inflation
	Accuracy of project program
	Third party delays
	Actual quantities of work
	Financial failure
	Contractor competence
	Differing site condition

Table 5. 7: Risk allocation as Practices - Appropriately Allocated

Risk Allocation	Risk Description
Contractor	Labor & equipment Productivity
	Labor disputes
	Labor, material& Equip. availability
	Coordination with subcontractors
	Safety/ Accidents
	Accuracy of project program
	Defective materials
	Quality of work
	Site access
	Adverse weather conditions
	Contractor competence
	Differing site condition
	Actual quantities of work
	Third party delays
	Changes in government regulations
	Inflation
	Delayed dispute resolutions
	Financial failure
	Acts of God
Shared	Permits & regulations
	Defective design
	Scope limitation & work definition
	Changes in work
Undecided	Delayed payment on contract
	Change order negotiations

From Table 5.5 and Table 5.6 it can be concluded that the perception of the contractors in allocating the surveyed construction risks is different from the actual practice of allocation. In practice, not a single risk is allocated to the owner and the contractor assumes most of the risks while in the contractors' opinion, they want to allocate some risks that they think the owner has better control over, like delayed payment on contract, change in work and scope limitation, and work definition. Also, contractors want owners to share more risks with them.

Tables 5.5 and 5.6 also show that some risks are consistently allocated to the contractor or shared. Six risks are consistently (both in perception and practice) allocated to contractors. These risks are mainly related to labor and equipment. They are namely:

1. Labor, material and equipment availability
2. Labor and equipment productivity
3. Defective material
4. Labor dispute
5. Safety / Accidents
6. Coordination with subcontractor

Acts of God is consistently wanted to be shared by the two parties.

Table 5.7 summarizes these results and shows that in contactors' perception, a total of three risks should be allocated to owners, seven risks should be allocated to contractors, four risks to be shared by the two parties, and a total of eleven risks were undecided. In practice, no risks

are allocated to owners, a total of seventeen risks are allocated to contractors, only two risks are shared, and four risks are undecided.

Table 5. 8: Summary of Risks Allocation - Perception Vs. Practice

	RISK ALLOCATION			
	Owner	Contractor	Shared	Undecided
Perception	3	6	4	12
Practice	0	17	2	6

The results of Tables 5.5 and Table 5.6 are shown in Figure 5.1 and Figure 5.2 respectively for easy representation and comparison.

Figure 5.1 shows that contractors in their perception want owners to assume 12% of the surveyed risks yet they do not decide on the allocation of 48% of the risks. Also, the figure shows that contractors want to retain 24% of the surveyed risks themselves and share 16% of the risks with owners.

Figure 5.2 shows that in practice, contractors assume 68% of the surveyed risks and owners do not assume any risk but they share 8% of the risks while 24% of the risks are undecided on the allocation.

This is a very interesting result and might be attributed to the idea that contractors are better in managing these risks. Another factor is the high competition in the market and the slow economy in the recent few years.

Table 5.7 is also represented in Figure 5.3 for easy comparison of the results.

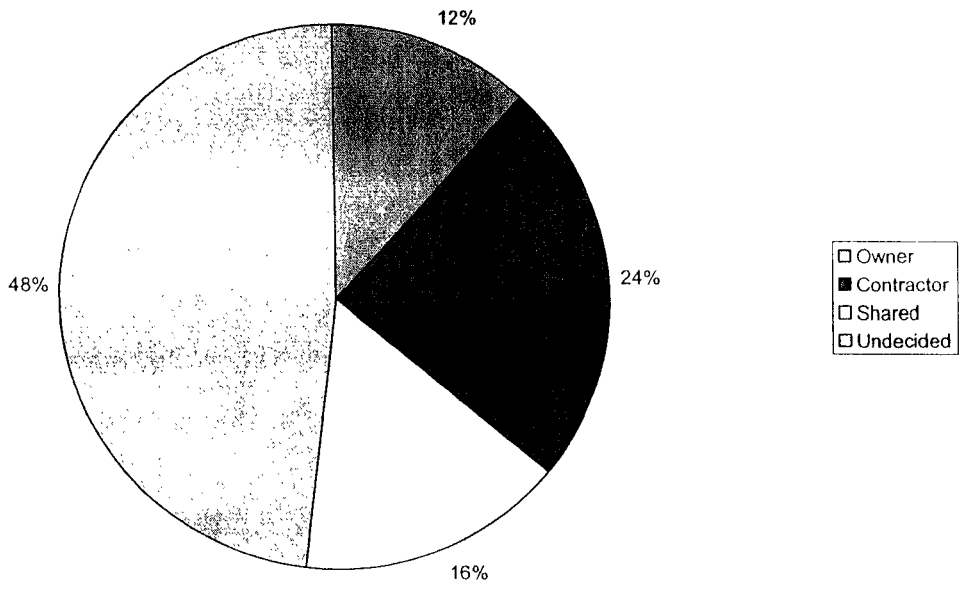

Figure 5. 1: Risk Allocation (Perception)

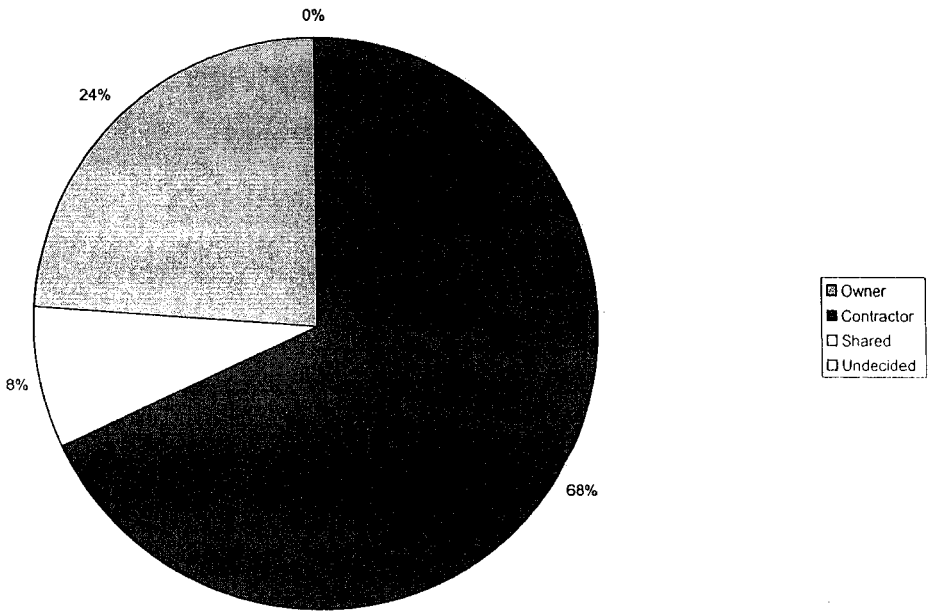

Figure 5. 2: Risk Allocation (Practice)

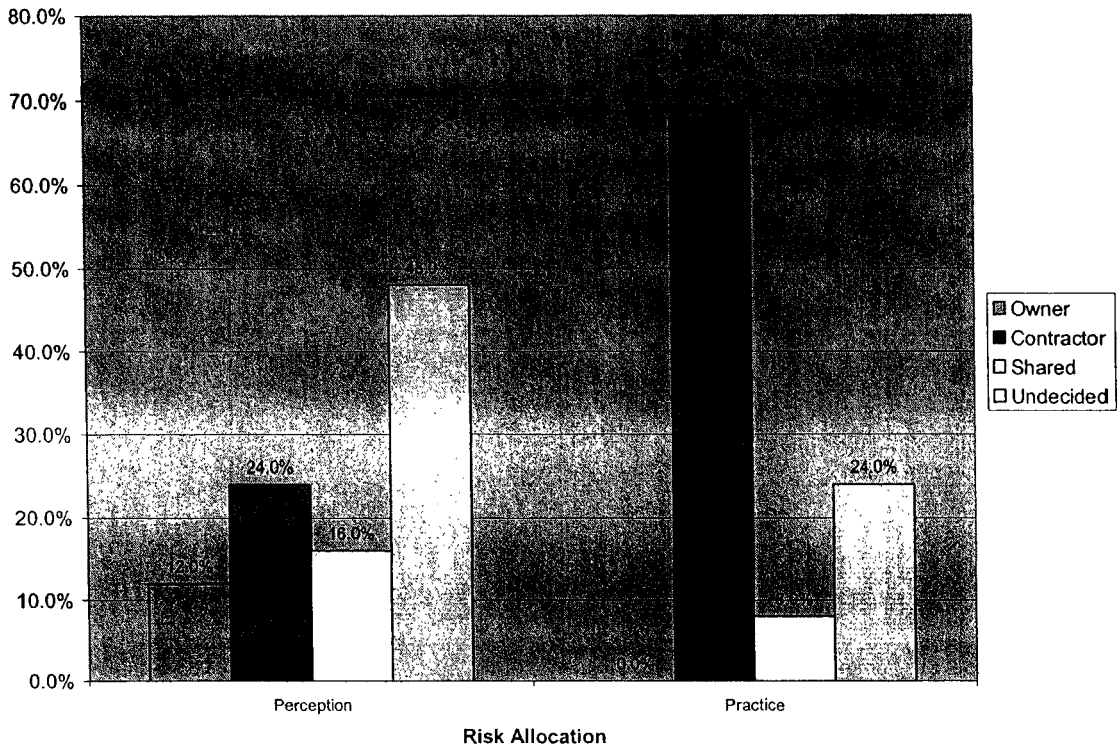

Figure 5.3: Risk Allocation (Perceptions Vs. Practice)

5.4.3 Part 3: Risk Importance

Tables 5.9 and 5.10 summarize the importance of these risks from the contractor's perception. Table 5.9 shows the frequency of each risk category in percentage. These results were then weighted and ranked to find the importance of each risk category and listed in Table 5.10.

Quality of work is considered the most important risk and is ranked first on the top of the list. All the respondents (100%) indicate that quality of work is the most important risk category as shown in table 5.9. Also, Table 5.10 shows that this risk is ranked first. This is anticipated because this is what matters most to the owner and this is what the contractor is paid for, to deliver quality project in accordance with the contact documents and specifications.

Similarly, for delayed payments on contract and financial failure, 89% of the respondents believe they are very important risks as shown in table 5.9. These two risk categories are very important for the contractor since any delayed payment or financial failure of any party of the contract will jeopardize the construction project. These risk categories are ranked second (tie) as shown in Table 5.10.

Acts of God and labor disputes are regarded as low important risks as shown in table 5.10. Because neither the owner nor the contractor has much control over acts of God, it is considered a low important risk. Also, this is since the area is not known for force majure conditions such as

volcanic activity or earthquake that are considered examples of acts of God. And, since both parties (contractor and owner) have strong faith in God (all Muslims), this risk category is considered low.

Labor dispute is also considered a low risk category (tie with acts of God) since labor disagreements are very minimal since the majority of the labor are foreigners and are controlled by strict rules of the contractor and government laws.

Adverse weather condition is considered the least important risk category because the area is not known for adverse weather conditions like, hurricanes, heavy snow or rain. Also, the weather is pleasant and stable most of the time.

The results of Table 5.9 are plotted on Figure 5.4 for better illustration of the results. The chart shows the weighted importance for each risk category.

Table 5. 9: Risk Importance

Risk Description	Very Important	Important	Less Important
Permits & regulation	44%	44%	11%
Site access	67%	22%	11%
Scope limitation & work definition	78%	22%	0%
Labor, material & Equip. availability	78%	22%	0%
Labor & equipment Productivity	63%	38%	0%
Defective design	75%	25%	0%
Changes in work	44%	56%	0%
Differing site condition	56%	33%	11%
Adverse weather conditions	22%	44%	33%
Acts of God	33%	33%	33%
Defective materials	56%	44%	0%
Changes in government regulations	33%	56%	11%
Labor disputes	11%	78%	11%
Safety/ Accidents	67%	33%	0%
Inflation	56%	33%	11%
Contractor competence	67%	33%	0%
Change order negotiations	67%	33%	0%
Third party delays	33%	67%	0%
Coordination with subcontractors	38%	63%	0%
Delayed dispute resolutions	56%	33%	11%
Delayed payment on contract	89%	11%	0%
Quality of work	100%	0%	0%
Financial failure	89%	11%	0%
Actual quantities of work	33%	67%	0%
Accuracy of project program	67%	33%	0%

Table 5. 10: Risk Importance Level

Risk Description	Rank	Weighted Importance	Importance Level
Quality of work	1	140	Most important
Delayed payment on contract	2	134	
Financial failure	2	134	
Scope limitation & work definition	4	128	
Labor, material& Equip. availability	4	128	
Safety/ Accidents	6	121	
Contractor competence	6	121	
Change order negotiations	6	121	
Accuracy of project program	6	121	
Site access	10	115	
Defective materials	10	115	
Defective design	12	112	
Changes in work	13	109	
Differing site condition	13	109	
Inflation	13	109	
Delayed dispute resolutions	13	109	
Labor & equipment Productivity	17	106	
Permits & regulation	18	103	
Third party delays	18	103	
Actual quantities of work	18	103	
Changes in government regulations	21	96	
Coordination with subcontractors	22	93	
Acts of God	23	84	
Labor disputes	23	84	
Adverse weather conditions	25	78	Least important

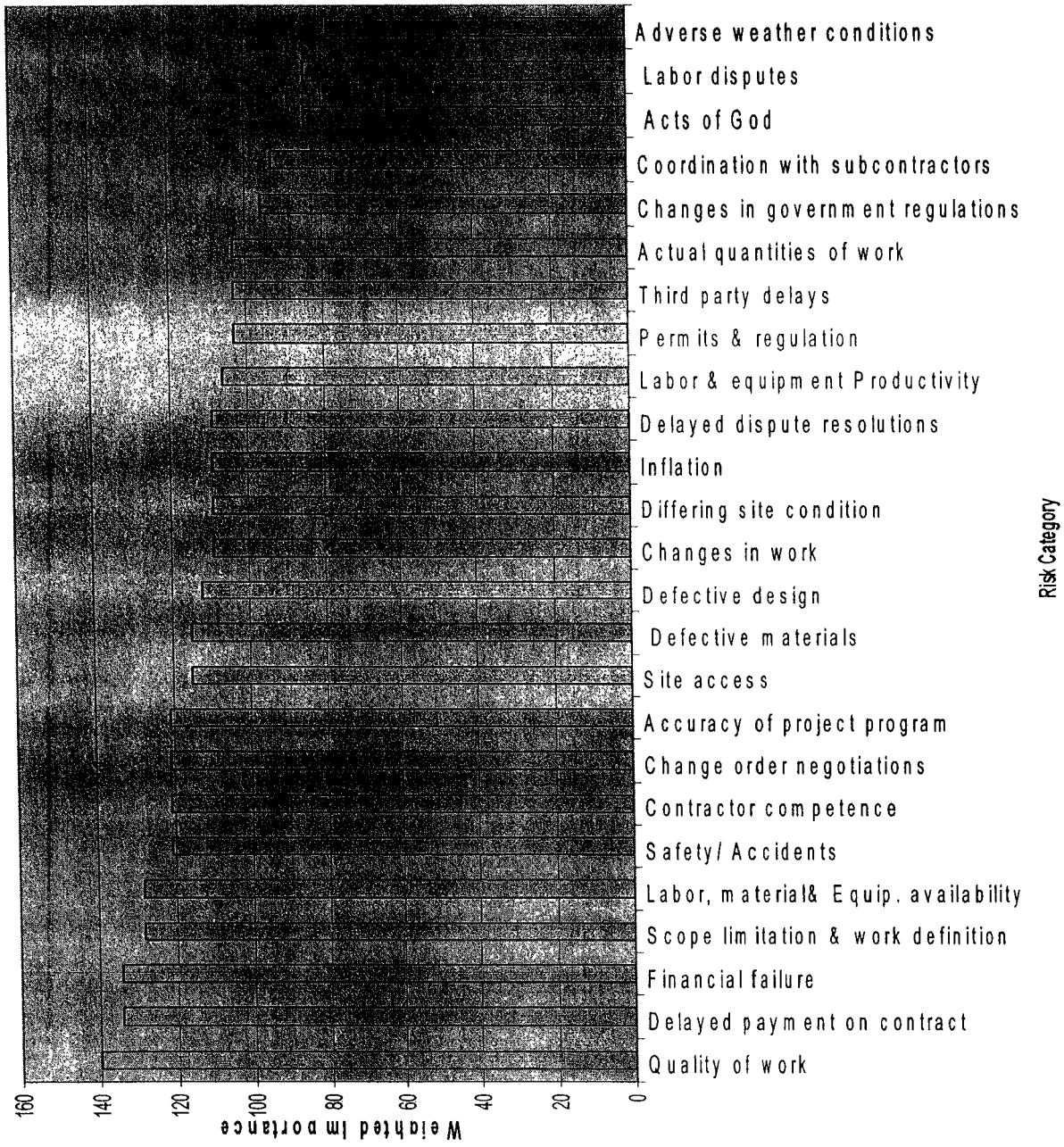

Figure 5. 4: Weighted Risk Importance

5.4.4 Part 4: Risk effects

This part discusses the effect of the different risk categories on the budget, schedule, safety and quality of the project. The frequencies of respondents are listed in Table 5.11 and represented in Figure 5.5 for better illustrations.

Table 5.11 indicates that safety received the least input from respondents, except for safety / accident risk where 41% of the respondents think this risk category directly affects the safety of the project. Also, from Table 5.11 no respondent thinks that scope limitation & work definition, change in work and quality of work will affect the safety of the project. Surprisingly, only 10% of the respondents think that defective design affects the safety of the project. Only 15% of the respondents think that coordination with subcontractors will affect the budget of the project while 64% of the respondents think that changes in government regulations affect the budget of a project.

Table 5.11 also shows that 62% of the surveyed contractors think permits and regulations affect the schedule of a project, and only 54% of the respondents think that coordination with subcontractors affects the schedule of the project.

Table 5. 11: Risk Effects

Risk Description	Risk effects			
	Budget	Schedule	Safety	Quality
Permits & regulation	23%	62%	15%	0%
Site access	23%	38%	31%	8%
Scope limitation & work definition	57%	36%	0%	7%
Labor, material& Equip. availability	32%	47%	11%	11%
Labor & equipment Productivity	38%	44%	0%	19%
Defective design	38%	29%	10%	24%
Changes in work	29%	53%	0%	18%
Differing site condition	29%	47%	12%	12%
Adverse weather conditions	33%	44%	11%	11%
Acts of God	40%	35%	15%	10%
Defective materials	26%	26%	16%	32%
Changes in government regulations	64%	29%	0%	7%
Labor disputes	18%	41%	18%	24%
Safety/ Accidents	24%	24%	41%	12%
Inflation	75%	17%	0%	8%
Contractor competence	29%	29%	14%	29%
Change order negotiations	56%	38%	0%	6%
Third party delays	29%	53%	0%	18%
Coordination with subcontractors	15%	54%	8%	23%
Delayed dispute resolutions	38%	50%	0%	13%
Delayed payment on contract	56%	31%	0%	13%
Quality of work	31%	19%	0%	50%
Financial failure	50%	43%	0%	7%
Actual quantities of work	57%	29%	0%	14%
Accuracy of project program	28%	50%	6%	17%

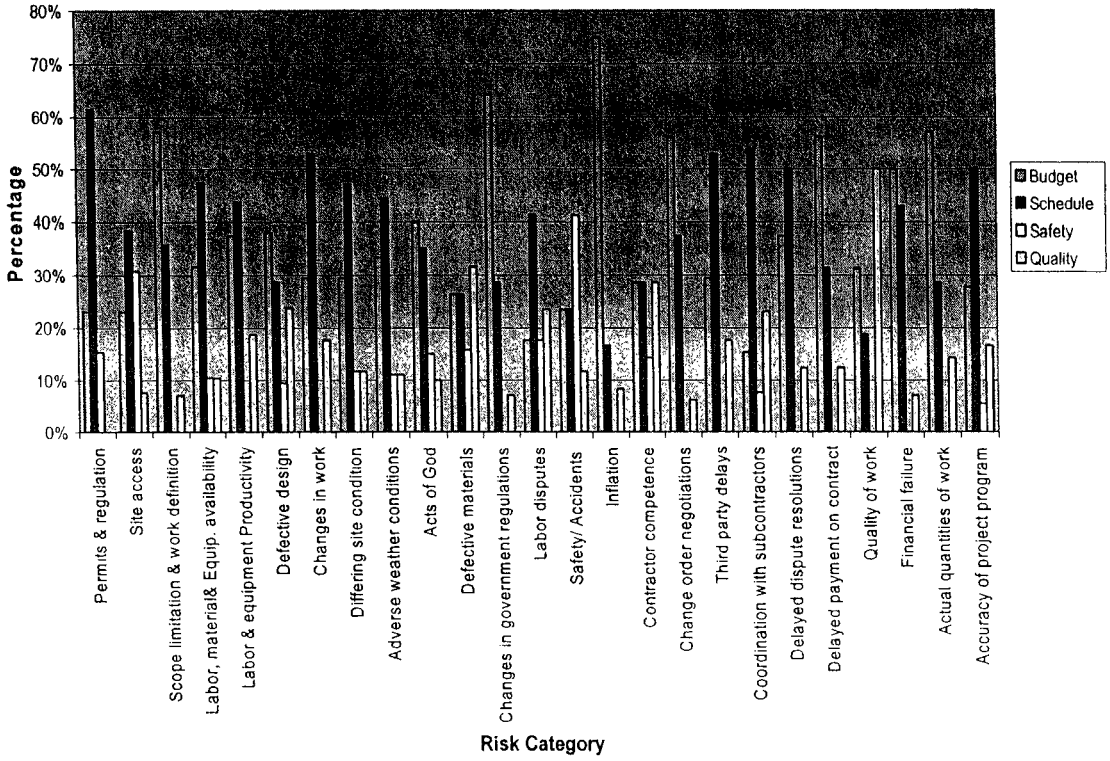

Figure 5. 5: Risk Effects

Table 5.11 shows that each risk category has an effect on a construction project in one or more of the listed project parameters (budget, schedule, safety and quality). The respondents' frequencies of risk effects shown in Table 5.11 will be appropriately assigned to one or more parameter if the frequency is more than 25%. In other words, for a risk category to be fully appropriated an effect on a project, it requires at least 25% response rate. If a risk category receives less than 25% response rate for any parameter, it will not be considered as to affect the project in that parameter. Table 5.12 shows the appropriated and ranked effects of the surveyed risks. Some of the surveyed risks have effects on a project in more than one aspect; for example a risk category might affect the budget, schedule and quality of a project. If a risk category has more effect on a project it will be ranked first.

Table 5. 12: Risk Effects (Appropriated and Ranked)

Risk Category	Risk Effects (appropriated and ranked)
Permits & regulation	Schedule
Site access	Schedule, safety
Scope limitation & work definition	Budget, schedule
Labor, material& Equip. availability	Schedule, budget
Labor & equipment Productivity	Schedule, Budget
Defective design	Budget, Schedule
Changes in work	Schedule, budget
Differing site condition	Schedule, budget
Adverse weather conditions	Schedule, budget
Acts of God	Budget, schedule
Defective materials	Quality, budget and schedule (tie budget & schedule)
Changes in government regulations	Budget, schedule
Labor disputes	Schedule
Safety/ Accidents	Safety
Inflation	Budget
Contractor competence	Budget, schedule and quality (tie for all)
Change order negotiations	Budget, schedule
Third party delays	Schedule, budget
Coordination with subcontractors	Schedule
Delayed dispute resolutions	Schedule, budget
Delayed payment on contract	Budget, schedule
Quality of work	Quality, budget
Financial failure	Budget, schedule
Actual quantities of work	Budget, schedule
Accuracy of project program	Schedule, budget

The responses on risk effects of all surveyed contractors in each risk category (Table 5.11) were analyzed to see the relative frequency of each project parameter (budget, schedule, safety and quality) on a project. This was done to see the effect of the risk categories on each parameter and compare the consequences. Table 5.13 shows risks effect on budget, schedule, safety and quality of a project with relative frequency. The table shows that the surveyed risks have more impact on the schedule of a project with a frequency of 38.5% while the same risks have the least effect on the safety of a project with a frequency of 8.5%. The results of Table 5.13 are graphed in Figure 5.6 to clearly show the risks effect frequencies for easy evaluation. From both the table and the graph, it can be seen that the surveyed risks have more effects on the schedule and budget of a project.

Table 5. 13: Risks Effect on Four Project Parameters

Risk Effect (1)	**Frequency** (2)	**Relative Frequency (%)** (2) / sum *100
Budget	467	36.8 %
Schedule	488	38.5 %
Safety	109	8.5 %
Quality	206	16.2 %
SUM	1269	100 %

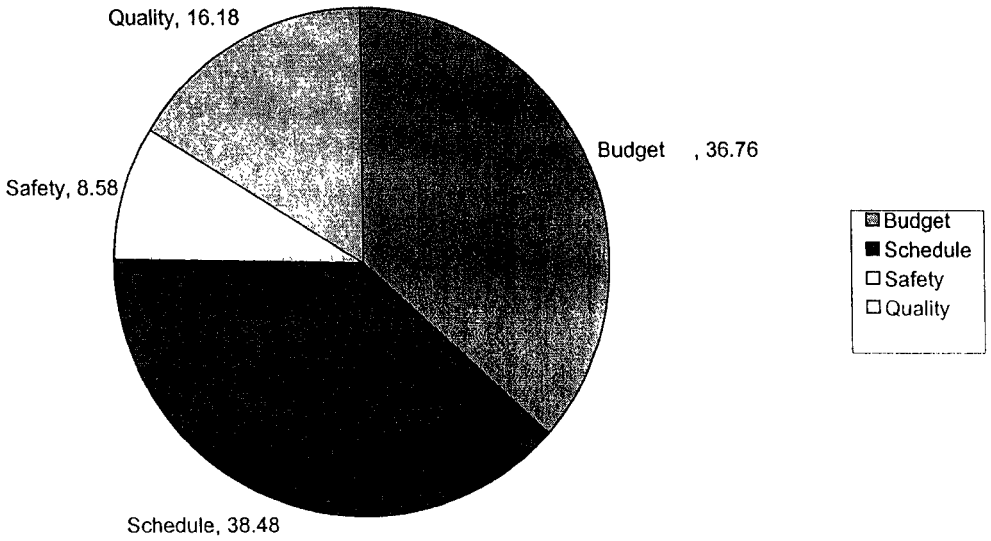

Figure 5.6: Risk Effects (Percentage)

5.4.5 Summary of the Survey Results

In this section, the results of the survey concerning risk allocation (both in practice and contractor's opinion or perception), risk importance and risk effects are summarized and tabulated in table 5.14 for quick reference and easy comparison.

Risk category is allocated to each party, as listed in Tables 5.5 and 5.6. Similarly, the importance of each risk category is assigned and ranked as listed in Table 5.8. Effects of each risk category on each parameter of the project are assigned if it weighs more than 25% since we have four parameters (budget, schedule, safety and quality). Some risk categories might affect more than one parameter of the construction project as shown in table 5.10

Table 5. 14: Summary of the Survey Results

Risk Description	**Risk Allocation** (Practice)	**Risk Allocation** (Perception)	**Risk Rank of Importance**	**Risk Effects**
Permits & regulation	Undecided	Undecided	18	Schedule
Site access	Contractor	Undecided	10	Schedule, safety
Scope limitation & work definition	Undecided	Owner	4	Budget, schedule
Labor, material & Equip. availability	Contractor	Contractor	4	Schedule, budget
Labor & equipment Productivity	Contractor	Contractor	17	Schedule, Budget
Defective design	Undecided	Undecided	12	Budget, Schedule
Changes in work	Undecided	Owner	13	Schedule, budget
Differing site condition	Contractor	Undecided	13	Schedule, budget
Adverse weather conditions	Contractor	Shared	Least important	Schedule, budget
Acts of God	Shared	Shared	23	Budget, schedule
Defective materials	Contractor	Contractor	10	Quality, budget & schedule
Changes in government regulations	Contractor	Undecided	21	Budget, schedule
Labor disputes	Contractor	Contractor	23	Schedule
Safety/ Accidents	Contractor	Contractor	6	Safety
Inflation	Contractor	Undecided	13	Budget

Table 5.14 Continued

Risk Description	Risk Allocation (Practice)	Risk Allocation (Perception)	Risk Rank of Importance	Risk Effects
Contractor competence	Contractor	Undecided	6	Budget, schedule & quality
Change order negotiations	Undecided	Shared	6	Budget, schedule
Third party delays	Contractor	Undecided	18	Schedule, budget
Coordination with subcontractors	Contractor	Contractor	22	Schedule
Delayed dispute resolutions	Contractor	Shared	13	Schedule, budget
Delayed payment on contract	Undecided	Owner	2	Budget, schedule
Quality of work	Contractor	Undecided	Most important	Quality, budget
Financial failure	Shared	Undecided	2	Budget, schedule
Actual quantities of work	Contractor	Undecided	18	Budget, schedule
Accuracy of project program	Contractor	Undecided	6	Schedule, budget

5.4.6 Part 5: Added risk categories

In section "C" of the questionnaire, the respondents were asked to add and rate any additional risk categories that they think should be added to the list. Five contractors responded to that section and five categories were added; one each.

These risks and the ratings are listed in table 5.15 bellow.

Table 5. 15: Added Risk Categories by Respondents

Risk Category	Allocation		Importance	Effect
	Perception	Practice		
Pre commissioning/ commissioning	Contractor	Contractor	Very important	Budget/schedule
Knowledge of owner /representative	Owner	Contractor	Very important	Budget/schedule/quality
Proper budgeting	Owner	Owner	Very important	Budget/schedule/quality
Cooperation of owner/decision maker	Owner	Contractor	Very important	Budget
Extension of schedule	Shared	Contractor	Very important	Schedule

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

Based on the results discussed in the previous chapter, the following conclusions were reached:

1- Risk assessment is a new concept to the construction contractors in Saudi Arabia. It is a relatively new concept to the construction industry world wide, based on the literature review.

2- The perception of construction contractors in Saudi Arabia and the common practice of allocating the surveyed 25 risk categories (listed in Table 5.6) are determined by this study. Similarly, the importance and effect of these risks are established. Risk allocations, risk importance and risk effects on construction projects are determined for the first time for the construction industry in this region of the world.

3- The perception of construction contractors in Saudi Arabia in allocating the surveyed risks is different from the common

practice of allocating these risks. In practice, most of the risks are allocated to contractors and none to owners.

4- Quality of work is the most important risk while an adverse weather condition is the least important risk.

5- The surveyed risks have the highest impact on the schedule of a project with a response frequency of 38.5%, while the same risks affect the safety of the project least (only with a response frequency of 8.5%)Most of the risk categories affect schedule and budget more than other project parameters.

6- Construction contractors in Saudi Arabia want owners to accept and share more risks with them. This can be attributed to two factors. First, owners have some control over some of the risks. For example, the Payment on contract, changes in work, and scope limitations and work definition. Second, because of the high competition in the market and slow economy in the recent few years.

6.2 RECOMMENDATIONS

As a result of this research, the following recommendations can be made:

1. All construction contractors in the Eastern Province of Saudi Arabia are encouraged to consider the results revealed by this research to have a better understanding when dealing with risks in the construction industry in this part of the world.
2. All construction industries in the Eastern Province of Saudi Arabia are advised to consider trends of allocation, importance and effect of important risk categories to help them facilitate proper management of these risks based on the results of this research.
3. Although this research was done in the Eastern Province of Saudi Arabia, the results and conclusions can be applied to the construction industry in other areas of Saudi Arabia because of the similarities of rules, regulations and business environment. Moreover, most of the construction contractors have offices in other areas of Saudi Arabia.

6.3 SUGGESTIONS FOR FURTHER STUDIES

Although this research discussed the most important aspects of assessments of risks management perception and practices of construction contractors in Saudi Arabia, some areas of this subject need further research. These studies might include:

- Similar study of assessments of risks management perception and practices of construction from the viewpoint of owners.
- Research of development of a Knowledge Based Expert System to manage the common and re-occurring risks in the construction industry in the region incorporating the expertise of the project managers, project engineers and owners. Such a system will help contractors and owners in the area.
- Consider including the added risk categories in the next study.

APPENDIX I

DEFINITION OF TERMS

1. **Risk Allocation:** Allocating and assigning the risk to each party of the contract.

2. **Risk Assessment:** Evaluation, review and appraisal of the possibility of loss, injury, disadvantage, damage or destruction.

3. **Risk Management:** The process of identifying and analyzing risks, determining the most appropriate techniques for handling those risks, implementing the techniques, and monitoring the results.

4. **Risk Avoidance**: (eliminating the risk) is abandoning or refusing to undertake an activity in which the risk seems too costly.

5. **Risk Reduction:** (minimizing the risk) consists of using various methods to reduce the probability that a given event will occur. Although some risks cannot be avoided, most can be appreciably reduced. The primary control technique is prevention, including the use of safety and protective techniques.

6. **Risk Transfer:** means shifting the consequences of a risk to persons or organizations outside your business. The best known form of risk transfer is **insurance,** which is the process by which an insurance

company agrees to pay an individual or organization an agreed upon sum of money for a prospective future loss.

7. **Risk Assumption**, also known as risk absorption or risk retention, involves the planned acceptance of the risk of loss. In some instances, reducing certain risks may be too expensive. Generally, the small business owner will assume risks in which losses that occur will not produce significant financial consequences to the business. Determining the amount of loss that is significant is not a precise science.

8. **Acts of God:** They include things that could happen beyond the control of human and might affect the construction projects like hurricanes, earthquakes, volcanic rupture and other natural phenomena.

9. **Change Order:** Formal alteration or modification order to alert original contract requirements.

10. **Pure Risks:** Are uncertainties as to whether some unpredictable event that can result in loss will occur. Pure risk can result only in loss, never in gain. This kind of risk consists of hazards such as a fire or a

hurricane, death of key employees, or customer injuries on the premises of the business. Pure risk exists when the possibility of loss is present, but the extent of the possible loss is unknown. Pure risk is different from speculative risk because speculative risk carries the possibility of gain as well as loss.

11. **Speculative Risks:** are uncertainties as to whether an activity will result in a gain or a loss. Risks, such as building a plant that turns out to have the wrong capacity or keeping an inventory level that turns out to be too high or too low, are speculative risks. Speculative risk is unavoidable and is inherent in the nature of the private enterprise system. They involve the possibility of Loss, No Loss or Gain

12. **Lump Sum Turn Key (LSTK):** A construction contract, which includes engineering, procurement, construction, construction management and commissioning of the project.

APPENDIX II

LIST OF CONTRACTORS

List #	CONTRACTOR	PHONE	FAX	Email	
1	Faisal Qahtani Sons	8873030	8824011	fmqco@sbm.net.sa	Khobar
2	United Contractors International	8822300	8826516		Khobar
3	Civil Works Limited	8572205	8574733	cwc@cwc.com.sa	Dammam
4	Yamamah for Construction	8270174	8270089	info@yamam.com	Dammam
5	Bader Al-Husain & Sons	8950776	8643472	alhussaini@ae.net.sa	Khobar
6	Jadawel International Limited	8944224	8945306	jadawel@ogertel.com	Dhahran
7	Swaed Itehad for Contracting Limited	8951513	8653522	alliedarms@hotmail.com	Khobar
8	Fobest Saudi	8270836	8270134	salpine@saudionline.com.sa	Dammam
9	Projects Systems Group for Construction	8334100	8324750	contactin@projects_system.com	Dammam
10	Mohammad Al Mojel Group	8421111	8425612	mmgho@mojilgrp.com	Dammam
11	M.& A. Bwardi Comp.	8335555	8336666	info@aldwardi.com	Dammam
12	Al-Mira Center for Trading	8273792	8276071	mustapha@almiracentre.com	Dammam
13	F. Al Khodri & Assos. For Construction	8952840	8986856	alkhodri@alkhodri.com	Khobar
14	A.N. Ben Ali for Construction	8266675	8265245	administrator@albinali.com	Dammam
15	Saudi S&S Lafaline	8825430	8825770	snc_lavalin.com	Khobar
16	Saudi-Denish Construction	8332339	8339881	atco@atco.com.sa	Dammam
17	TRADCO for Trading	8820415	8822839	corporate@tradco.com.sa	Khobar
18	Tamimi Construction	8474050	8471592	tamimi.h.o@tamimi.gels.com	Dammam
19	Arabian Gulf for Structural Limited	8471383	8472112		Dammam
20	Arabian Gulf for General Construction	3613113	3611116	sales@albuainain.com	Jubail
21	Sure Way for Construction	8821288	8821290	marketing@sure track.com.sa	Dammam
22	Derbas for Roads & Maintenance	8827227	8827239	roads@alderbas.com	Khobar
23	Al Rashed for Contracting	8994466	8572370	falfakhri@hotmail.com	Khobar

List	CONTRACTOR	PHONE	FAX	Email	CITY
24	Al-Rabiah & Al-Nassar	8993338	8949164	east@rancogroup.com	Khobar
25	Raziza for Trading	8644960	8949620	saleziza@reziza.com	Khobar
26	Saudi Cyprus Company for Construction	8573540	8573556	sccdamho@scc.sa.com	Dammam
27	Saudi Company for Civil works	8950644	8951416	ssem@sps.net.sa	Khobar
28	Saudi Company Services Limited	8871222	8821574	ssoc@asg-group.com	Dhahran
29	Consolidated Contractors Co.	8580174	8580185	vhajeir@ccc.com.sa	Khobar
30	Dubaib and Sulaim Co. (DSCO)	8588989	8581666	Tawfiq@dsco-sa.com	Khobar
31	NESMA	8971050	8947825	Will.nolan@nesma.com	Khobar
32	Modern Arabian Company for Construction	8822233	8825804	maconstr@zajil.net	Khobar
33	Top for Structural construction	8822677	8822980		Khobar
34	Ka'abi for Contracting	8271193	8263716	kaabi@mail.com	Dammam
35	Eastren Establishment for Trading	8572345	8572596	tet@zajil.net	Khobar
36	Buildings- General Contractor	8917793	8916703		Dhahran
37	Al-musehel Limited	8570999	8581333	sales@almisehal.com	Dammam
38	TEKFEN Construction & Installation Co.	8829694	8829695	tekfensab@nesma.net.sa	Dammam
39	Al-Mshareq for Trading & Contracting	8421660	8421658		Dammam
40	Al-Mutlaq for Trading & Contracting	8571945	8574006	almutlaq@almutlaq.com	Dammam
41	General Contracting	8820888	8871000	ecc@olayangroup.com	Khobar
42	Modern Arabian Contractors	8822233	8825956	macorp@zajil.net	Khobar
43	Saudi Arab Contractors Limited	8579780	8572904		Khobar
44	Al Maha Contracting	8335517	8335592	president@aqua mozoon.com	Dammam
45	Muhaideb Contracting	8260345	8262144	muhcont@zajil.net	Dammam

List	CONTRACTOR	PHONE	FAX	Email	City
46	Rezayat Company	8824656	8874435	pabl@pabl.com.sa	Khobar
47	Salman Al-Duhaim Est.	3401124	3401126	info@salduhaim.com	Jubail
48	Arabian Daio Limited	8983275	8952429	dazwooco@zajil.net	Dhahran
49	Raymond-Saudi Arabia Limited	8829997	8822006	info@raymondsaudi.com	Khobar
50	FAFCO Contracting	8173000	8173300	fafco@abdulla-fouad.com	Khobar
51	Sa'ad for Trading & Contracting	8822220	8827989		Khobar
52	S. Al-Sodun Contracting	8423020	8422772	saddounest@sps.net.sa	Dammam
53	C.B.E Arabian Limited	8330990	8335836	wbliss@chicagobridge.com	Dammam
54	Abdullah Nas & co. Limited	3412096	3411495	anp-majed@awalnet.net.sa	Jubail Industrial
55	A. Al-Turki for Contracting & Trading	8335588	8339881	atco@atco.com.sa	Dammam
56	A. Al Qasaib Contracting Co.	8822220	8570244		Khobar
57	A. Bu-Boshait & co for Contracting	8263185	8262855	bushait@sahara.com.sa	Dammam
58	Abdullah A. Al-Dossary	8829027	8825761	info@aldossary.com.sa	Khobar
59	A. Al-Khodri & Sons Contracting	8950048	8942427	alkhodariandsons@zajil.net	Dammam
60	A. Fouad Limited	8324400	8345722	info@abdulla-fouad.com	Dammam
61	A. M. Al-Otaishan & Sons	8571600	8579960		Dammam
62	Al-Dabal Company for Contracting	8260578	8271580		Dammam
63	A. M.Al-Harbash	8647774	8641962	info@al-tamimi.net	Dhahran
64	A. Al-Qahtani & Co.	8580909	8577184	aqm@q3group.com	Dammam
65	Gulf Pan Saudi Co.	8940444	8982497	sales@saudipangulf.com	Khobar
66	O. Al-Ghamdi & sons Co.	8421176	8432058	sec@ohggroup.com.sa	Dammam
67	H.K. Al-Sadiq Sons Co	6670701	6673140	sadiqnetx@sol.net.sa	Ras Tanura
68	Arnaout Contracting Est. (ARCON)	8940336	8647185	arcon@zajil.net	Khobar
69	Arabian FAL for Contracting Co.	6672080	6670990	corporate@arabianfal.com	Rahimah
70	SHADE company	8350100	8343910	hassan@shadeco.com	Khobar

List	CONTRACTOR	PHONE	FAX	Email	City
71	Saudi Arabian Ketanah Broths.	8940191	8944301	kbsa@sahara.com.sa	Khobar
72	Saudi Condrico Limited	8578874	3588920	almacon@concept.net.sa	Dammam
73	Road Constructing Establishment	8642137	8983401	rccltd@yahoo.com	Khobar
74	Maice Saudi Limited	8948887	8982584	saudimace@awalnet.net.sa	Khobar
75	Al-Sroor Group	8655596	8655584	info@alsuroor.com	Khobar
76	Al-Zayer Company	8544298	8547278		Qatief
77	Mohammad S. Al-Swaidi	6670304	6671855	gdo@suwaidi.com	Ras Tanura
78	M. A. Al-Khafrah & Broths. Company	8336677	8345418	alkobarah@zajil.net	Dammam
79	Nesma & Al Fadhel Contracting	8971050	8947825	asunaid@nesma-alfadl.com	Khobar
80	H. A. Al-Otaibi Establishment	8944533	8982808	otaibiest@zajil.net	Dhahran
81	Arabian Worli Limited	8948700	8987116	mail@worleyarabia.com	Khobar
82	Al-Maha'an Trading & Contracting Co.	8575685	8571194		Khobar

Note: Names are translated from the Arabic original. Thus, pronunciation might be slightly different.

APPENDIX III

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APPENDIX IV

SURVEY QUESTIONNAIRE

Ministry of Higher Education

King Fahd University of Petroleum & Minerals

COLLEGE OF ENVIRONMENTAL DESIGN

Dept. of Construction Engineering & Management

وزارة التعليم العالي

جامعة الملك فهد للبترول و المعادن

كلية تصاميم البيئة

قسم هندسة وإدارة التشييد

Dear, Project Manager

The Department of Construction Engineering and Management at King Fahad University of Petroleum and Minerals is conducting a research titled "Assessments of Risks Management Perception and Practices of Construction Contractors in Saudi Arabia "

The purpose of this study is to shed some light on the perception and attitude of the typical construction contactor in the Eastern Province of Saudi Arabia towards construction risks. It is mainly concerned with the allocation of risks, risk importance and their effects on the project. Also, to improve the understanding of local contractors of risks related to construction industry.

You are kindly invited to participate in this study by completing the attached questionnaire. We will be highly grateful to you if you could return the completed questionnaire on or before March 1st, 2003 to any of the addresses below.

We promise that any information or opinion that you will be given to us will be held in a strict confidence and used for research purpose only.

Should you have any question or clarification regarding this research, please contact the undersigned.

Dr. S. Assaf
Professor, CE&M Department
KFUPM
P.O. Box, 680
Dhahran, 31262
Saudi Arabia
Tel. (03) 860-3593; Fax (03) 860-4453

E-mail: assaf@kfupm.edu.sa

Engr. A. Al Salman
Saudi Aramco
P. O Box 1513, ABSC
Abqaiq, 31311
Saudi Arabia
Tel. (03) 572-4357
Fax (03) 572-3727

E-mail: ali.salman.2@aramco.com

Thank you for your anticipated cooperation.

SURVEY QUESTIONNAIRES

B. General Background Information

It is highly recommended that a project manager or a project engineer, if possible, completes this survey, for better results.

In this research, lump sum type of contract is assumed.

Note: Responses to questions and company, project and individual will remain anonymous.

1- Name of the Company / Establishment

_____

2- Number of Employees

☐ 10-50 ☐ 51-100 ☐ 101-150 ☐ More than 150

3- Gross net value (approximate in 1000 Saudi riyals)

_____

4-Individual completing the questionnaire:

Name: _____ (optional)

Organization: _____

Title: _____

Telephone #: _____, Fax _____

E-mail _____

5- How long has the company been in the construction industry?

☐1-5 Years ☐6-10 Years ☐more than 10 Years

B- Risk Allocation. Importance & Risk Effects Questionnaire:

The responses to each question are divided into three groups: risk allocation, risk importance and effect of that risk on the project. In risk allocation, two responses are requested. First, your opinion as a Project Manager/ Project Engineer. Second the normal practice of allocating these risks in your firm.

Please rate the following questions that you think most appropriate
In a scale 1 to 10 where 10 being the highest and represents the most important risk factor and 1 represents the least important.

1- Permits and regulations

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

2-Site access

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

3- Scope limitation and work definition:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

4- Labor, Material And Equipment Availability:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

5- Labor And Equipment Productivity:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

6- Defective Design:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

7- Changes In Work:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

8- Differing Site Condition:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

9- Adverse Weather Conditions:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

10- Acts of God:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

11- Defective Material:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

12- Changes In Government Regulations:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

13- Labor Dispute:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

14- Safety / Accidents:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

15- Inflation:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

16- Contractor Competence:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

17- Change-Order Negotiations:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

18- Third Party Delays:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

19- Coordination with Subcontractors:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

20- Delayed Dispute Resolution:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

21- Delayed Payment On Contract:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

22- Quality of work:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

23- Financial failure:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

24- Actual quantities of work:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

25- Accuracy of project program:

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

D- Please, add and rate any additional risk category that you think should be added for the questionnaire:

Risk category: _____

In YOUR opinion this risk is best allocated to ☐Owner ☐Contractor ☐Shared

However, in PRACTICE this risk is mostly allocated to ☐Owner ☐Contractor ☐Shared

This risk is ☐Very important scale(8-10) ☐Important(scale 4-7) ☐Less important(scale1-3)

This risk mostly affects ☐Budget ☐Schedule ☐Safety ☐Quality

A copy of the results of this study will be sent to you upon your request.
Please, feel free to contact us if you have any question regarding this study, at the following details:

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Thank you for your anticipated cooperation.

APPENDIX V

PRINTOUT OF MICROSOFT EXCEL CALCULATIONS

Risk Allocation (Perception) Ranked and percentile

Point	*(Perception) Weighted*	*Rank*	*Percent*
21	127.551	1	100.00%
7	115.107	2	95.80%
3	108.885	3	91.60%
23	96.441	4	87.50%
1	96.421	5	83.30%
4	90.219	6	75.00%
6	90.219	6	75.00%
8	90.219	8	70.80%
5	83.997	9	62.50%
13	83.997	9	62.50%
2	83.997	11	54.10%
16	83.997	11	54.10%
11	77.775	13	41.60%
12	77.775	13	41.60%
18	77.775	13	41.60%
24	71.553	16	37.50%
15	71.553	17	29.10%
19	71.553	17	29.10%
14	65.331	19	25.00%
25	59.109	20	20.80%
22	55.998	21	16.60%
9	52.887	22	8.30%
10	52.887	22	8.30%
17	40.443	24	4.10%
20	34.221	25	.00%

Risk Allocation (perception) Ranked and Percentile using Microsoft Excel

Risk	*Owner*	*Rank*	*Percent*	*Point*	*Contractor*	*Rank*	*Percent*	*Point*	*Shared*	*Rank*	*Percent*
21	22	1	100.00%	5	28	1	95.80%	17	25	1	95.8%
3	19	2	91.60%	13	28	1	95.80%	20	25	1	95.8%
7	19	2	91.60%	4	25	3	91.60%	10	22	3	91.6%
6	16	4	83.30%	19	22	4	87.50%	9	19	4	87.5%
23	16	4	83.30%	11	19	5	79.10%	12	16	5	75.0%
12	12	6	79.10%	14	19	5	79.10%	15	16	5	75.0%
1	12	7	75.00%	16	16	7	70.80%	25	16	5	75.0%
2	9	8	58.30%	22	16	7	70.80%	6	12	8	62.5%
8	9	8	58.30%	8	12	9	66.60%	18	12	8	62.5%
15	9	8	58.30%	1	9	10	50.00%	24	12	8	62.5%
18	9	8	58.30%	2	9	10	50.00%	2	9	11	45.8%
10	6	12	45.80%	24	9	10	50.00%	14	9	11	45.8%
16	6	12	45.80%	25	9	10	50.00%	22	9	11	45.8%
24	6	12	45.80%	7	6	14	33.30%	23	9	11	45.8%
4	3	15	25.00%	9	6	14	33.30%	1	6	15	20.8%
9	3	15	25.00%	18	6	14	33.30%	3	6	15	20.8%
11	3	15	25.00%	21	6	14	33.30%	8	6	15	20.8%
17	3	15	25.00%	3	3	18	16.60%	11	6	15	20.8%
25	3	15	25.00%	15	3	18	16.60%	16	6	15	20.8%
5	0	20	.00%	20	3	18	16.60%	19	6	15	20.8%
13	0	20	.00%	23	3	18	16.60%	7	3	21	16.6%
14	0	20	.00%	6	0	22	.00%	4	0	22	.00%
19	0	20	.00%	10	0	22	.00%	5	0	22	.00%
20	0	20	.00%	12	0	22	.00%	13	0	22	.00%
22	0	20	.00%	17	0	22	.00%	21	0	22	.00%

Weighted Risk Importance Ranked and Percentile using Microsoft Excel

Risk Description	*Weighted Importance*	*Rank*	*Percent*
22	140	1	100.00%
21	134	2	91.60%
23	134	2	91.60%
3	128	4	83.30%
4	128	4	83.30%
14	121	6	66.60%
16	121	6	66.60%
17	121	6	66.60%
25	121	6	66.60%
2	115	10	58.30%
11	115	10	58.30%
6	112	12	54.10%
7	109	13	37.50%
8	109	13	37.50%
15	109	13	37.50%
20	109	13	37.50%
5	106	17	33.30%
1	103	18	20.80%
18	103	18	20.80%
24	103	18	20.80%
12	96	21	16.60%
19	93	22	12.50%
10	84	23	4.10%
13	84	23	4.10%
9	78	25	.00%

Risk Importance Ranked and percentile using Microsoft Excel

Point	Very Important	Rank	Percent	Point	Important	Rank	Percent	Point	Less important	Rank	Percent
22	28	1	100.0%	13	22	1	100.0%	9	9	1	95.8%
21	25	2	91.6%	18	19	2	91.6%	10	9	1	95.8%
23	25	2	91.6%	24	19	2	91.6%	1	3	3	66.6%
3	22	4	83.3%	7	16	4	79.1%	2	3	3	66.6%
4	22	4	83.3%	12	16	4	79.1%	8	3	3	66.6%
2	19	6	58.3%	19	16	4	79.1%	12	3	3	66.6%
6	19	6	58.3%	1	12	7	66.6%	13	3	3	66.6%
14	19	6	58.3%	9	12	7	66.6%	15	3	3	66.6%
16	19	6	58.3%	11	12	7	66.6%	20	3	3	66.6%
17	19	6	58.3%	5	9	10	29.1%	3	0	10	.0%
25	19	6	58.3%	8	9	10	29.1%	4	0	10	.0%
5	16	12	37.5%	10	9	10	29.1%	5	0	10	.0%
8	16	12	37.5%	14	9	10	29.1%	6	0	10	.0%
11	16	12	37.5%	15	9	10	29.1%	7	0	10	.0%
15	16	12	37.5%	16	9	10	29.1%	11	0	10	.0%
20	16	12	37.5%	17	9	10	29.1%	14	0	10	.0%
1	12	17	29.1%	20	9	10	29.1%	16	0	10	.0%
7	12	17	29.1%	25	9	10	29.1%	17	0	10	.0%
10	9	19	8.3%	2	6	19	12.5%	18	0	10	.0%
12	9	19	8.3%	3	6	19	12.5%	19	0	10	.0%
18	9	19	8.3%	4	6	19	12.5%	21	0	10	.0%
19	9	19	8.3%	6	6	19	12.5%	22	0	10	.0%
24	9	19	8.3%	21	3	23	4.1%	23	0	10	.0%
9	6	24	4.1%	23	3	23	4.1%	24	0	10	.0%
13	3	25	.00%	22	0	25	.00%	25	0	10	.0%

VITA

Ali Al Salman was born in Alhassa, Saudi Arabia in December 1962. Upon graduation from high school, he joined Saudi Aramco. In 1986 he went to the United States to continue his education. He received his Bachelor of Science degree in Mechanical Engineering in May 1990 from the University of Portland in Portland, Oregon. After graduation he served different roles in Saudi Aramco as Rotating Equipment Engineer, Design Engineer and Project Engineer in various oil and gas facilities. Currently, he works as a Safety/ Loss Prevention Engineer for the Loss Prevention Department of Saudi Aramco.