Chapter 3

Research Methodology

3.1 Introduction

The preceding chapter described in some detail the concepts and the practices of risk management in construction projects for full understanding of risk management concepts and practices. In this chapter, a description of data collection procedure adopted for this research is described. This chapter also provides the information about research strategy, research design, target population and sample size. It also discusses some of the practical problems encountered. A detailed methodology and tools used are described.

3.2 Research Strategy

Chambers English Dictionary defines research as (Fellows & Liu, 1997):

- a careful search
- investigation
- Systematic investigation towards increasing the sum of knowledge.

Research is diligent, systematic inquiry or investigation to validate old knowledge and generate new knowledge (Burns & Grove, 1987). Research dose not occur in a vacuum, research projects take place in context – of researcher's interests, expertise and experiences;of human contacts ; of the physical environment, etc (Fellows & Liu, 1997).

Research strategy can be defined as the way in which the research objectives can be questioned (Naoum, 1997).

There are two types of research strategies namely quantitative research and qualitative research (Naoum, 1997). Quantitative approaches seek to gather factual data and to study relationships between facts and how such facts and relationships accord with theories and the findings of any research executed previously (Fellows & Liu, 1997), where qualitative approaches seek to gain insights and to understand people's perception of "the world" whether as individuals or groups (Fellows & Liu, 1997). Qualitative research is "subjective" in nature, emphasizing meanings, experiences and so on (Naoum, 1997).

In this research, a quantitative approach is selected to determine the variables and factors that affect the risk management practices in building projects in Sudan to find out if there is a systematic risk management practices through the contracting companies.

3.3 Research Design

The term "research design" refers to the plan or organization of scientific investigation, designing of a research study involves the development of a plan or strategy that will guide the collection and analyses of data (Polit & Hungler, 1999). Burns & Grove (1997) defined the term design as "some consider research design to be the entire strategy for the study, from identifying the problem to find the plans for data collection. Other limit design to clearl define structural framework within which the study is implemented". The framework that the researcher creates is the design (Wood & Haber, 1998). Much research in the social sciences and management spheres involves asking and obtaining answers to questions through conducting surveys of people by questionnaires, interviews and case studies (Fellows & Liu, 1997).

In this research a closed-ended questionnaire with interview is used to collect data from respondents. In structured interview, questions are presented in the same order and with the same wording to all interviewees. The interviewers have full control on the questionnaire throughout the entire process of the interview (Naoum, 1998).

In structured interview, the interviewer administers a questionnaire, perhaps by asking the questions and recording the responses, with little scope for probing those responses by asking supplementary questions to obtain more details and to pursue new and interesting aspects (Fellows & Liu, 1997). Naoum (1998) summarizes the main advantages of structured interview as follows:

1. The answers can be more accurate.
2. The response rate is relatively high (approximately 60-70 percent), especially if interviewees are contacted directly.
3. The answers can be explored with finding out "Why" the particular answers are given.

3.4 Research Population

A population consists of the totality of the observation with which we are concerned (Walpole & Myers, 1998). In this research, the population is the some of number of contractors who have valid registration by the Contractors Union and the same number of clients..

3.5 Sample Size

Sampling defines the process of making the selections; sample defines the selected items (Burns & Grove, 1987). Wood and Haber (1997) defined the sampling as the process of selecting representative units of a population for the study in a research investigation. Scientists derive knowledge from samples; many problems in scientific research cannot be solved without employing sampling procedures (Wood & Haber, 1997).

Unfortunately, without a survey of the population, the representativeness of any sample is uncertain, but statistical theory can be used to indicate representativeness (Fellows & Liu, 1997). One of the most frequent questions asked "what size sample I use?" historically, the responses to this question at least 30 subjects. However, in most cases 30 subjects will be inadequate as a sample size (Burns & Grove, 1987).

A statistical calculation was used in order to calculate the sample size. The formula below was used to determine the sample size of unlimited population (Creative Research Systems, 2001):

$$SS = \frac{Z^2 \times P \times (1-P)}{C^2}$$

Where SS = Sample Size.

Z = Z Value (e.g. 1.96 for 95% confidence interval).

P = Percentage picking a choice, expressed as decimal, (0.50 used for sample size needed).

C = Confidence interval (0.05)

$$SS = \frac{1.96^2 \times 0.5 \times (1-0.5)}{0.05^2} = 384$$

Correction for finite population

$$SS_{New} = \frac{SS}{1 + \frac{SS-1}{pop}}$$

Where pop is the population

$$SS_{New} = \frac{384}{1 + \frac{384-1}{45}} = 40.36 \approx 40$$

questionnaires are distributed to contracting firms. To carry out a comparison between contractors and clients' perspectives, the same number of questionnaires will be distributed to clients.

3.6 Sample Method

The objective of sampling is to provide a practical means of enabling the data collection and processing components of research to be carried out whilst ensuring that the sample provide a good representation of the population (Fellows & Liu, 1997) Simple sampling was used to represent the total sample size, since it is the most basic of the probability plans. A list of contractors was obtained from Sudanese Contractors Union ..

3.7 Limitation Of The Research

1. Due to time limitation, this research is concerned with building projects only and will not take into account that other categories of construction industry like heavy engineering construction (tunnels, bridges, dams, etc.), industrial projects (factories and workshops), and infra-structure projects (sewage and water supply.)

2 .This research is limited to the contractors who have a valid registration through the Sudanese Contractors Union..

3. This study is limited to the construction industry practitioners in Sudan.

3.8 Research Location

Construction firms in Khartoum state were selected for investigation due to the state's position as the center of construction firms in Sudan, as well as for reasons of practicality and convenience perceived by the researcher

3.9 Questionnaire Design

The questionnaire survey was conducted to determine the opinion of contractors, clients and other regarding the risk factors. A four pages questionnaire accompanied with a covering letter were delivered to contracting companies and clients (clients could be: ministries, municipalities, consultants, and so on).

The letter indicates the objectives of the research and explained to the participants that the results of the questionnaire would be used to improve the ability of contractors and clients to identify, analyze and estimate the risk factors impact on the construction phase of building projects.

A close-ended questionnaire was used for its advantages as it is easy to ask and quick to answer, they require no writing by either respondents or interviewer.

The questionnaire was composed of five sections to accomplish the aim of this research, as follows:

1.The organization profile

2.Risk factors that have been identified by literature, experts and by the researcher.

3.Risk preventive methods which could be used to avoid risk to take place.

4.Risk mitigative methods that could be used to mitigate risk impact or likelihood.

5.Risk analysis techniques that could be used to analyze and estimate risk factors impact.

The questionnaire was prepared in English language (Appendix 1), but for the interest of the research and to have more accurate results the questionnaire were translated into Arabic (Appendix 2), as most of the target population are not familiar with the English language. To ensure obtaining complete and meaningful response to the questionnaire an interview was conducted with each respondent to explain the objective of the study and to get input towards the questionnaire design, especially towards identifying risk types and management actions for controlling these risks. Some of the questionnaires were filled throughout the interview. In addition, their analysis is straight forward (Naoum, 1998). A draft questionnaire, with 36 risk factors , prepared from literature and distributed into nine groups – by adding two groups to the literature (Hillson, 2002); political and construction - to best fit the nature of the industry in Khartoum was discussed with the supervisor who requested adding more factors and test validity content by knowledge experts and local construction practitioners in Khartoum . Content validity was conducted by sending the draft questionnaire with covering letter to experts to evaluate the content validity of questionnaire, to check readability, offensiveness of the language and to add more factors and information if needed . As a result, good comments regarding the shape and the factors were taken into consideration and 12 additional factors were added and 4 were omitted to reflect the nature of construction industry in Kahrtoum. These factors were amalgamated with the original factors and the required modifications have been introduced to the final questionnaire. A total of 44 factors were distributed into nine groups. To form the final questionnaire (Appendix 1) .

3.9.1 Construction Risk Allocation

There are different types of risks associated with the construction activities. These are physical, environmental, design, logistics, financial, legal, political, construction and management risks (Perry & Hayes, 1985, cited in Kartam, 2001). Table (3.1) illustrates different types of risk included in the questionnaire. To get input towards the questionnaire design, especially towards identifying risk types, rather than the related literature. Some of the literature's risk types such as floods, earthquakes, wind damages and pollution were not included in this study because of inapplicability.

3.9.2 Significance Of Risk And Measurement Scales

The degree of impact for each risk type was included in the questionnaire under the heading "Significance". The questionnaire was designed to examine practitioners' observations and judgments in determining the relative significance of each risk category. Although the degree of impact varies from project to project, the questionnaire is expected to elicit a general assessment of the significance of risk. Each respondent was required to rank each risk on a scale from 1 to 10 by considering its contributions to project delays. Scale 1 t10 is selected to obtain a greater level of suppleness in choosing statistical procedures (Wood& Haber, 1998). Rank 1 is assigned to a risk would give the lowest contributions to risk consequences while Rank 10 is allotted to a risk that would cause the highest contribution. In the same time rank (1-3) means low importance risks, ranks (4-7) for medium risks and (8-10) for high risks.

Table 3.1. Risk variables (factors) included in the questionnaire

Construction Project Risk	*Physical*	Occurrence of accidents because of poor safety procedures
		Supplies of defective materials
		Varied labor and equipment productivity
	Environmental	Environmental factors (floods, earthquakes,…, etc.)
		Difficulty to access the site (very far, ….. etc)
		Adverse weather conditions
	Design	Defective design (incorrect)
		Not coordinated design (structural, mechanical, electrical, etc.)
		Inaccurate quantities
		Lack of consistency between bill of quantities, drawings and specifications
		Rush design
		Awarding the design to unqualified designers
	Logistics	Unavailable labor, materials and equipment
		Undefined scope of working
		High competition in bids
		Inaccurate project program
		Poor communications between the home and field offices (contractor side)
	Financial	Inflation
		Delayed payments on contract
		Financial failure of the contractor
		Unmanaged cash flow
		Exchange rate fluctuation
		Monopolizing of materials due to unexpected political conditions
	Legal	Difficulty to get permits
		Ambiguity of work legislations
		Legal disputes during the construction phase among the parties of the contract
		Delayed disputes resolutions
		No specialized arbitrators to help settle fast
	Construction	Rush bidding
		Gaps between the Implementation and the specifications due to misunderstanding of drawings and specifications
		Undocumented change orders
		Lower work quality in presence of time constraints
		Design changes
		Actual quantities differ from the contract quantities
	Political	New governmental acts or legislations
		Unstable security circumstances
	Management	Ambiguous planning due to project complexity
		Resource management
		Changes in management ways
		Information unavailability (include uncertainty)
		Poor communication between involved parties

In order to quantitatively demonstrate the relative significance of risks to a project, a weighting approach is adopted. The principle is that the risk with the highest contribution rank would be assigned the largest weight. The figures in brackets in Table (3.2) are weighted scores for each risk at different contribution rank. Each individual's weighted score is obtained by multiplying the number of respondents with the corresponding weight. The figures in the last column of the table give the total weighted scores for each risk. The rank range of 1 to 3 denotes risks that are not significant, 4 to 7 indicates significant risks and 8 to 10 shows very high significant risks.

Table 3.2 – An example for contribution of risks to a project (risk significance).

Types of risks	**Contribution rank**										**Total weighted scores**
	1	2	3	4	5	6	7	8	9	10	
Defective materials	2 (2)	0 (0)	3 (9)	1 (4)	8 (40)	5 (30)	4 (28)	4 (32)	2 (18)	2 (20)	183
Inaccurate quantities	2 (2)	0 (0)	0 (0)	1 (4)	1 (5)	1 (6)	9 (63)	4 (32)	7 (63)	6 (60)	235

3.9.3 Risk Management Actions

Managing risks means minimizing, controlling, and sharing of risks, and not merely passing them off onto another party (Fisk, 1992, cited in Katram, 2001). The methods of managing risks are retention, transfer, mitigation, and prevention of risks or any combination thereof. There are two kinds of management actions: preventive action and mitigative action. Preventive actions are used to avoid and reduce risks at the early stage of project construction, yet they may lead to submitting and excessive high bid for a project. Where the study is concerned with the construction phase; the survey addressed mitigative actions are remedial steps aimed at minimizing the effects of risks through the construction phase. The survey presents six mitigative actions. These actions were generated based on related research work on construction risk management.

3.9.3.1 Preventive Actions

Table (3.3) illustrates the seven preventive methods that proposed to respondents to measure the effectiveness for each. Preventive actions are used to avoid and reduce risks at the early stage of project construction, yet they may lead to submitting an excessive high bid for a project. The relative degree of effectiveness between the methods will be quantitatively demonstrated as shown previously.

Table 3.3 – Relative effectiveness of preventive methods

Preventive method	Effectiveness of preventive methods						Total weighted scores
	Very high	High	Moderate	Low	Very low	In applicable	
	5	4	3	2	1	0	
Depend on subjective judgment to produce a proper program.	15 (75)	8 (32)	...	...	...	...	...
Produce a proper schedule by getting updated project information	...	...	...	...	...	...	...
Refer to previous and ongoing similar projects for accurate program.	...	...	...	...	...	...	...
Consciously adjust for bias risk premium to time estimation	...	...	...	...	...	...	...
Plan alternative methods as stand-by.	...	...	...	...	...	...	...
Utilize quantitative risk analyses techniques for accurate time estimate.	...	...	...	...	...	...	...
Transfer or share risk to/with other parties	...	...	...	...	...	...	...

3.9.3.2 Mitigative Actions

Whilst some project delay risks can be reduced though various preventive actions at early stages, the delay of progress still occurs in many projects during the construction process. A recent industry study has indicated that over 80% of projects exceed their scheduled time even with the employment of software techniques for project development (Katram, 1992). When delay happens, contractors can adopt various mitigative actions to minimize the effects of the delay. Table (3.4) represents the six mitigative methods being proposed to the respondents to measure the effectiveness for each of the methods. The relative degree of effectiveness between the methods will be quantitatively demonstrated as shown previously.

Remedial method	Effectiveness of remedial methods						Total weighted scores
	Very high	High	Moderate	Low	Very low	In applicable	
	5	4	3	2	1	0	
Increase manpower and/or equipment	15 (75)	8 (32)	...	...	...	...	...
Increase the working hours	...	...	...	...	...	...	...
Change the construction method.	...	...	...	...	...	...	...
Change the sequence of work by overlapping activities	...	...	...	...	...	...	...
Coordinate closely with subcontractors	...	...	...	...	...	...	...
Close supervision to subordinates for minimizing abortive work.	...	...	...	...	...	...	...

Table 3.4 Relative effectiveness of mitigative methods

3.9.4 Risk Analysis Techniques

Table (3.5) below shows the risks analysis techniques. Respondents were asked to determine the relative use of those techniques. Six methods were included to highlight the construction industry practitioners concerns about risk analysis and its approaches.

Table 3.5 – Relative effectiveness of risk analysis techniques

Risk analysis techniques	Use of risk analysis techniques						Total weighted scores
	Very high	High	Moderate	Low	Very low	In applicable	
	5	4	3	2	1	0	
Direct judgment using experience and personal skills	15 (75)	8 (32)	...	...	...	...	...
Comparing analysis (compare similar projects through similar conditions)	...	...	...	...	...	...	...
Probability analysis (analyze historical data)	...	...	...	...	...	...	...
Expert Systems (including software packages, decision support systems, computer-based analysis techniques such as Risk	...	...	...	...	...	...	...
Sensitivity analysis	...	...	...	...	...	...	...
Simulation analysis using simulator computer packages	...	...	...	...	...	...	...

3.10 Validity Of Research

Validity refers to the degree to which an instrument measures what it is supposed to be measuring (Pilot and Hungler, 1985). High validity is the absence of systematic errors in the measuring instrument. When an instrument is valid; it truly reflects the concept it is supposed to measure (Wood and Haber, 1998). Validity has a number of different aspects and assessment approaches (Polit and Hangler, 1985). Below, several routes to evaluating an instrument's validity are listed:

- Content validity
- Criterion-related validity
- Construct validity

Questionnaire was reviewed by two groups of experts. The first was requested to identify whether the questions agreed with the scope of the items and the extent to which these items reflect the concept of the research problem. The other was requested to identify that the instrument used is valid statistically and that the questionnaire was designed well enough to provide relations and tests between variables. The two groups of experts do agree that the questionnaire was valid and suitable enough to measure the concept of interest with some amendments, the most important of which are:

- 12 additional risk factors were added to the questionnaire and 4 were omitted due
to recurrence and ambiguity.
- 7 preventive methods were added.

3.11 Reliability Of Research

Reliability of an instrument is the degree of consistency with which it measures the attribute it is supposed to be measuring (Polit & Hunger, 1985). The less variation an instrument produces in repeated measurements of an attribute, the higher its reliability. Reliability can be equated with the stability, consistency, or dependability of a measuring tool. The test is repeated to the same sample of people on two occasions and then the scores obtained were compared by computing a reliability coefficient (Polit & Hunger, 1985). For the most purposes reliability coefficients above 0.7 are considered satisfactory. Period of two weeks to a month is recommended between two tests (Burns & Grove, 1987). Ten questionnaires were re-distributed among contractors and clients . The reliability coefficient was (0.90) in the contractors case and (0.87) in clients' which indicates a high level of reliability and the correlation was significant at 0.01 level.

3.12 Data Collection

Data collection was based on personal interview for filing questions. The personal interview, which is a face-to-face process, in which the respondents were asked questions with a brief explanation for the ideas and contents of questionnaire, was conducted. The number of respondents who agreed to cooperate was 63 out of 80 which represent 79 % of the over all sample. On the contractors side the ratio was 78%, and on the clients' was 80%.

3.13 Data Analysis

Analysis is an interactive process by which answers to be examined to see whether these results support the hypothesis underlying each question (Backstorm and Cesar, 1981 cited in Hallaq, 2003). Quantitative statistical analysis for questionnaire was done by using Statistical Package for Social Sciences (SPSS). The analysis of data is done to rank the severity of causes of contractor's failure in Khartoum . Ranking was followed by comparison of mean values within groups and for the overall sub-factors. The opinion of contractors regarding the severity of each cause was checked by analysis of variance (ANOVA).

The following statistical analysis steps were done:

- Coding and defining each variable
- Summarizing the data on recording scheme
- Entering data to a work sheet
- Cleaning data
- Mean and rank of each cause
- Comparing of mean values for each main group and overall sub-factors
- ANOVA test was done to test the difference of answers of contractors regarding to variables
- Partial correlation test was done to compare the mean values of different groups
- Multi-comparison test was also done when there is a significant difference