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Ph.D. Thesis

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Method of Determining Risk List (Identification) and Risk Controlling by Lean Tools for Iraqi Construction Projects

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Abstract

The main topic of this work is an experimental study on the construction site. The current study is a new method that was not followed previously in addressing the risk factors of delay and cost overrun of construction projects in Iraq, where the researcher collected the most important of these risks in a new manner, not only through research in the Iraqi environment, but also in some Asian countries as well, because of the similarities in the work environment and its circumstances. The researcher also used multiple methods in order to define the risks, which is one of the objectives of the research, and then determine the most important and most influential projects, where 36 risks were identified, distributed among twelve risk groups that included the most important factors that directly affect the delay or increase in the cost of the project. The researcher designed a questionnaire that includes these Risks in order to evaluate them, as 512 respondents responded effectively to their importance and seriousness in the implementation of the business. The statistical analysis in assessing the risks and their correlation with each other are used, and obtaining conformity the two hypotheses of the study. The researcher also prepared a supplementary questionnaire distributed to the experts to obtain their opinion about the extent to which these risks were discovered by the project management. In order to develop a new method for dealing with construction risks in Iraq projects, the researcher defined the lean risk management tools and identified the most important fifth tools that deal with 79.6 % of the specific risks, and this is one of the most important goals of the research. The researcher created this method to be a new method to be followed in Iraqi projects to reduce a good percentage of waste time and costs overrun after the project manager performs a periodic review to assess the risks and according to the risk management model (RMM) suggested by this study.

Keywords : construction management, risk factors, cost overrun, delay schedule, questionnaire, lean management, Iraqi projects

Streszczenie

W rozprawie zaprezentowano wyniki badan przeprowadzonych wśród uczestników budowlanego procesu inwestycyjnego. Opracowano nową metodę, która wcześniej nie była stosowana w zarzadzaniu czynnikami ryzyka wpływającymi na opóźnienia i przekroczenia kosztów projektów budowlanych w Iraku. Doktorant zgromadził najważniejsze dane o tych czynnikach ryzykach, nie tylko poprzez badania w środowisku irackim, ale także w niektórych krajach azjatyckich. Było to możliwe, ze względu na podobieństwa w środowisku pracy i jego warunkach. Doktorant użył również kilku metod, aby zdefiniować ryzyka, co było jednym z celów badań. Następnie wybrał najistotniejsze projekty, gdzie zidentyfikowano 36 czynników ryzyka. Podzielono je na dwanaście grup, które obejmują najważniejsze czynniki bezpośrednio wpływające na opóźnienia lub wzrost kosztów projektu. Celem ich oceny Doktorant opracował ankietę, która obejmowała te ryzyka, a 512 respondentów skutecznie określiło ich znaczenie i wagę w realizacji przedsięwzięcia. Użyto analizy statystycznej w ocenie ryzyk i ich wzajemnych korelacji, a także uzyskania zgodności z dwoma postawionymi hipotezami rozprawy doktorskiej. Doktorant przygotował także dodatkową ankietę, rozesłaną do ekspertów, celem uzyskania ich opinii na temat stopnia, w jakim te ryzyka wpływają na zarządzanie projektem. Celem dodatkowej ankiety było opracowanie nowej metody radzenia sobie z ryzykiem w procesie budowlanym w projektach irackich, Doktorant opracował narzędzie zarządzania ryzykiem, którego skuteczność w radzeniu sobie z konkretnymi czynnikami ryzyka wyniosła 79,6%, było to jednym z najważniejszych celów przeprowadzonych badań. Doktorant opracował tę metodę jako nową metodę do stosowania w projektach realizowanych w Iraku. Celem opracowanej metody było zmniejszenie ilości traconego czasu oraz przekroczeń kosztów. Taki wynik uzyskuje się poprzez prowadzenie przez kierownika projektu okresowych ocen ryzyka, zgodnie z modelem zarządzania ryzykiem (RMM), opracowanym w rozprawie.

Słowa kluczowe: zarządzanie w budownictwie, czynniki ryzyka, przekroczenia kosztów, opóźnienia w harmonogramie, badania ankietowe, projekty w Iraku

Preface

This research work was carried out at the Production and Management Engineering department of the Faculty of Civil Engineering at Warsaw University of Technology under the supervision of Professor Michał Krzemiński, Ph.D., DSc.

Identifying the most important construction risks that hinder the progress of construction projects in Iraq is the focus of the study of this thesis. The method of conducting the questionnaire used in this study and the results are reviewed in the sixth and seventh chapters, respectively. The second axis is studying the most important lean tools for reducing and controlling risks and reviewed in chapter eight.

Contents

Abbreviations

RM – risk mangement

RMM – risk management model

RMIS – risk management information system

JIT – just-in-time

TQM – total quality management

DMAIC – define-measure-analysis-improve-control

LSS – lean six sigma

IFC – iraqi federation of contractors

QMSs – quality management systems

1 Introduction

1.1 Overview

Iraqi is witnessing rapid changes and development in the construction sector, especially after 2003; accordingly, most construction projects are becoming larger and more complex. During any construction project, the three inter-related factors of time, money, and quality need to be controlled and managed. Good control means that all three factors could be improved simultaneously.

To stay competitive and on the first level, companies state or local have to focus their strategies on strategic advantages through the enhancement of work excellence and performance. Risk Management (RM) provides an effective approach to achieving this goal.

Risk management is one of the nine knowledge areas propagated by the Project Management Institute [1]. Managers on a project must decide on acceptable targets for each of these factors and take action to ensure that they are achieved. Also, rapid changes have made companies adopt a clear vision, thus enabling them to see the future and forcing them to apply specific strategies to ensure that they can grow in the right way. Risk Management depends on the perception and sources of the risk in all phases of a project. Furthermore, risk management in the construction project management context is a comprehensive and systematic way of identifying, analyzing and responding to risks to achieve the project objectives [2,3]. The benefits of the risk management process include improvement of construction project management processes and effective use of resources. The risk is a constant process in many organizations' systems and updating throughout the project duration. The construction industry is a major user of formal project risk management practices, yet the risk is often dealt with inadequately, which is a contributory factor to poor performance.

Conceptual developments propose a holistic view of risk incorporating threats and opportunities and the management of uncertainty. To optimize a risk management process there needs to be a reflection of this holistic view in management practice [4].

1.2 Statement of the problem

The present study focuses on the risk factors in the context of the construction industry. The main rationale for the selection of this area of study is the role that the construction industry plays in the development of any country and economy through the provision and development of the infrastructure of the countries.

The construction industry has been one of the most important industries for the development of the Iraqi superstructure and infrastructure and economy in the seventies and eighties last century before the gulf war.

In Iraq especially, Risk management is considered one of the most important approaches to the success of the construction industry because of political and economic changes and wars. However, there is a lack of understanding of managing the located risks and discovering and dealing with any new factors that could be making changes to cost, quality, or time of the construction.

Risks in the construction industry need to be under control in various areas such as site, transport materials, observation of quality, and many things more.

Mismanagement of risks results in any of these areas can potentially lead to significant issues in the whole industry.

But having some previous experience and knowledge of risk control represents a powerful way of solving the problems related to unforeseen risk factors. Therefore, it is important to adopt a system that offers a platform for this aspect to be addressed the most effective risks that currently face the Iraqi construction sector.

On another side, risk management helps to insure receiving the final product according to the predefined requirements. Although these requirements may differ according to the product nature in general, they represent the customer's interests. Therefore, contractors and consultants are responsible to do their best to conform to these requirements according to the contractual agreement with their customers, otherwise, it will be considered a breach of contract.

So, this study provides an important vision associated with the implementation of risk management in the construction industry in Iraq and gives the recommendation to be a reference in the future management of the risk in Iraqi construction sites.

However, most contractors have failed in meeting stakeholders' needs on cost, quality, and time objectives [5].

The failure of these objectives is caused by design deficiencies, product failure, mismanagement of quality, poor workmanship, and other many factors these problems are common and faced by most countries irrespective of the differences in their economies and the failure percentage may be multiplied in the huge projects as uncertainties in project outcome results [6,7].

In the construction industry, managing risks are generally considered to be not very costly in comparison to risks that happened without any risk plan to manage or control, and some construction companies are established for this purpose (manage and control risks).

In Iraq they are no clear vision to plan and manage or identify the risks in construction.

This study seeks to fill this gap by identifying the critical risk factors and developing a model for an effective risk management implementation in the construction industry in Iraq.

Thus, this study is founded on the fact that risk management has been implemented in some countries and was yielded enormous benefits, then its implementation in the construction industry in Iraq will improve risk practices and encourage continuous improvement hence, effective risk management will guide them in achieving their project goals.

1.3 Outcome of the study

The principal outcome of this study is to develop a risk management model (RMM) for the introduction in Iraqi construction companies which will identify the risks and manage as a tool to assess a company's strengths and weaknesses with regard to its use of RM. Applying this model will lead to continuous improvement in risk control and reduce the risk effects.

1.4 Objectives of the study

The specific objectives of this study are:

- To identify the risk factors that exist in this sector.
- To assess current practices of RM in the Construction Industry from the perceptions of the main actors of the construction industry in Iraq
- To identify the risk factor effects on project time.
- To identify the risk factor effects on project cost.

This serves as the basis and reference point for implementing a risk management model and how to improve it.

1.5 Questions of the study

The specific questions to the study include:

Q1: What is the impact of the factors on cost overruns of the construction projects?

Q2: What is the impact of the factors on the delay in completing the construction?

Q3: How often does it appear?

Q4: What is the impact of these factors on the occurrence of other risks? (Remaining groups)?

1.6 Hypotheses of the study

In view of the above-mentioned questions, the study tests the following hypothesis using a T-test and parsons' correlation according to respondent party:

First hypothesis

H_1: There is a significant difference in perception between the participants with regard to the risk factors affecting projects costs.

H_0: There is no significant difference in perception between the participants with regard to the risk factors affecting the projects costs.

Second hypothesis

H_1: There is a significant difference in perception between the participants with regard to the risk factors affecting projects schedule.

H_0: There is no significant difference in perception between the participants with regard to the risk factors affecting the projects schedule.

1.7 Significance of study

Based on the study problem, there is a need to develop a management model of RM and assess Iraqi construction companies' strengths and weaknesses with regard to RM.

It is noticed that there are a number of problems in the construction industry one of the causes is by mismanagement risks. Projects are frequently late, over budget, and suffer from poor workmanship and materials. Conflict is increasing, resulting in litigation and arbitration with depressing regularity. The failure of many companies happened due to these problems.

RM (Risk Management) is a subset of project management that includes the process required to satisfy the needs and complete them within a specific time and budget.

Finally, the results obtained from this study will assist future efforts to develop and build a concrete RM for the construction sector in Iraq.

1.8 Outline of methodology

The study adopted both quantitative and qualitative approaches spanning the following processes:

In the preliminary process, an extensive literature review on the subject matter of the study was undertaken. The literature review covered the management structure of the construction sector in Iraq and the Middle East, concepts of quality, and RM (Risk Management) in the construction sector to the surface.

Based on the literature review on both sides of Iraq and the Middle East, a standardized questionnaire is developed to collect data about the RM practices and the perception of factors contributing to the successful implementation of RMM (Risk Management Model).

The targeted respondents are investors, contractors, sub-contractors, and engineers of active construction companies. Application of semi-structured interviews with several representatives from different areas within the construction industry to collect information about their claims of the most serious problems that they are facing in the current situation. These interviews were selected following a study carried out by Latham in the United Kingdom for similar purposes [8]. The methods employed as well as the questionnaire design and development processes are detailed in chapters Three, Four, Five, and Six of the theses.

In chapter Seven, the data collected from the questions will present and classified, and analyzed using Statistical Package for Social Scientists (SPSS v26). Correlation analysis and hypothesis testing will be present and detailed in the chapter.

In Chapter Eight, lean risk thinking is applied as an approach to address risk factors and the Lean Six Sigma approach to prioritizing risk factors by using the failure mode and effect analysis (FMEA)and calculating the risk priority number RPN. The Pareto Analysis is used to Identify Risk Categories Ranking & Contribution.

Finally, and ultimately the establishment of Chapter Nine includes the risk management model (RMM) as the final output of the research.

1.9 Organization of the study

The study comprises ten (10) chapters and these have been organized as follows; Chapter one (current) deals with the introduction to the research including background to the study, statement of the problem, outcome, and objectives of the study, key questions, study hypotheses, the significance of the study, study methodology, and organization of the study. Chapter two includes two phases, the first introduces the risk concept in the construction industry, it also reviews the fundamentals of RM necessary for a greater understanding of the concepts and an in-depth review of the critical risk factors for RM implementation. The second phase introduces an introduction to lean thinking and the lean risk concept and how the study will develop a risk management model (RMM) and control risk. Chapter three addresses the study methodology adopted and concept is described including the design of the instrument and the method for collecting and analyzing the relevant data. Chapter four represents an analysis of the data of the RM research survey in Asia as currently practiced and critical risk factors that identified, and then allocate the most effective factors on cost and time construction for 5 years till now. Chapter five represents data analysis of the results of the RM research survey in Iraq as currently practiced and critical risk factors identified to allocate the most affected factors on cost and time construction for 5 years till now. Chapter six shows the development and describe the elements of the questionnaire. Chapter seven analyses the data collecting from the questionnaire output. Chapter eight presents the lean risk and lean tools applied to control risks. Chapter nine represented the risk management model (RMM) in details. Finally, Chapter ten contain the thesis summary, lesson learned and future research.

2 Risk concept and the opportunity to decrees the uncertainty by lean thinking

2.1 The Risk concept

The Risk concept is an uncertain event that, if it occurs, influences a construction project primary targets of cost, time and quality, therefore the project objective's will not be achieved as planned. It follows that a realistic estimate makes appropriate allowances for all those risks and uncertainties that can be anticipated from experience and foresight. Project managers should undertake or propose actions that eliminate the risks before they occur or reduce the effects of risk or uncertainty and make provision for them if they occur when this is possible and cost-effective. It is vital to recognize the root causes of risks, and not to consider risks as events that occur almost at random [9].

In general, the risks exist in different percentages or degrees of risk in every project, regardless of project size or complexity. Identifying potential project risks usually starts by reviewing the estimating assumptions made by the project Estimator and by the design team. Each risk must be properly identified and analyzed and, if necessary, add a contingency reserved in the construction total cost estimated. if the risks are not properly identified and treated throughout project development, risk can play a main role in causing inaccurate cost estimates or cost deviation, which are key in Mega or moderate construction projects. The project team should actively manage the risks and update the contingency estimate throughout the project development or life cycle.

The purpose of project risk management is to obtain better project outcomes and results, in terms of schedule, cost and operations performance. The project risk management process is needed but not limited to ensure that:

- Allocate the resources in order to make a general assessment for all risk types of overall risks and the related.
- If the manager and team taking into account the opportunities to address more than one risk.
- If the process itself and the risk treatment strategies are implemented cost-effectively.
- Define the most important risk can discover it from the pre-initiating process that at least can ensure the project can be a success if the response to it on time.
- In pre-initiating and initiating project proses all stakeholders must know and understand the Identified risks with both the range of potential consequences they represent and the likelihood

of values in that range being determined as far as is necessary and important for decision-making.

The recommended approach to project risk management is consistent with the approach adopted for a wide range of other risk management processes. The application of those processes to projects requires the integration of risk management with project management processes and activities [10].

2.1.1 Risk management

Risk Management depends on the perception and sources of the risk in all phases of a project. The risk is a constant process in many organizations' systems and updating through the project duration. The success of many organizations is becoming increasingly dependent on the success or failure of the software they build. In this environment, managing risk is not only a sound development practice but also a vital business practice [11, 12].

Whenever the risk management processes are used, they are often simplistic, and users have little trust in the results of their risk analysis results. Given the increasing interest in risk management in the software industry, for applying risk management more widely, it is important to provide comprehensive support for risk management, guidelines for achievement or application, support communications between the stakeholders and be credible.

In software engineering literature there seems to be a consensus of the activities that compose the risk management process [11, 13, 14]. It is important to notice that all activities are based and cantered on communication and is used by project teams to identify and handle the risk on their project. This is a cyclical and continuous process composed by:

2.1.2 Risk Management Plan.

The goal of this activity is deciding how to plan the project’s risk management activities, resource allocations, teamwork, and documentation standards.

2.1.3 Risk Identification.

Determining the risks that might affect the project and documenting their characteristics. In this activity, many techniques to collect risk are assigned in the literature.

2.1.4 Risk Response Plan

Risk is involved with the failure or loss but also considers the possibility that the outcome of certain risks may be an opportunity. This activity determines how to exploit and enhance opportunities and minimize lost.

2.1.5 Risk Monitoring and controlling

It is an important activity, as well as checks all risks are identified and to identify new risks in the environment throughout the process. Evaluate and executing and effectiveness of risks responses plans. It is essential to notice that well-defined schedules are very important to achieve the success of this activity

2.1.6 Risk Communicate

The communication between software project teams and stakeholders is one of the most important factors for the successful accomplishment of risk management. Risks, problems and crises can appear, when the communication structure is weak in the organization environment [13].

In general risk exists at two levels within every project. Each project contains individual risks that can affect the achievement of project objectives. It is also important to consider the riskiness of the overall project, which arises from the combination of individual project risks and other sources of uncertainty [15].

2.1.7 Classifications of Risk

According to the managerial literature and practice, there are a lot of risk classifications that have been put forward in. The important of them are:

1. The Risks classified based on the effects resulting from the event occurrence. On this basis, it distinguishes between the economic and non-economic risks.
2. The Risks classified based on the criterion of the nature or origin of the potentially unfavourable event. Based on this criterion, risks have been distinguished by some as technical and economic.
3. The dynamic and static risks are linked to failure or losses caused by the improper action of nature and errors and misunderstandings by human beings.

Additionally, the Risks classified based on the class or nature of the economic result from the event. They are broken down as according to:

- Liability risks: events entailing a legal liability.
- Personal risks: events involving physical risks for people.
- Property risks: these relate to the destruction, damage, the disappearance of the property with resulting costs and loss of earnings [16].

2.1.8 The effect of risk management

If the problems or uncertainties included in the early stages of a cost estimate do materialize, then a higher range of the cost estimate will be expected. In contrast, when risk management and other cost control processes are used effectively, a lower range of expected costs will result.

The figure below depicts how identifying, quantifying, and managing risks can impact the cost of project. If risks were not properly identified and managed throughout the design process, the cost to deliver the project will typically be higher. Likewise, opportunities that are ignored prevent the ability to take advantage of circumstances that could have lowered the overall cost of the project.

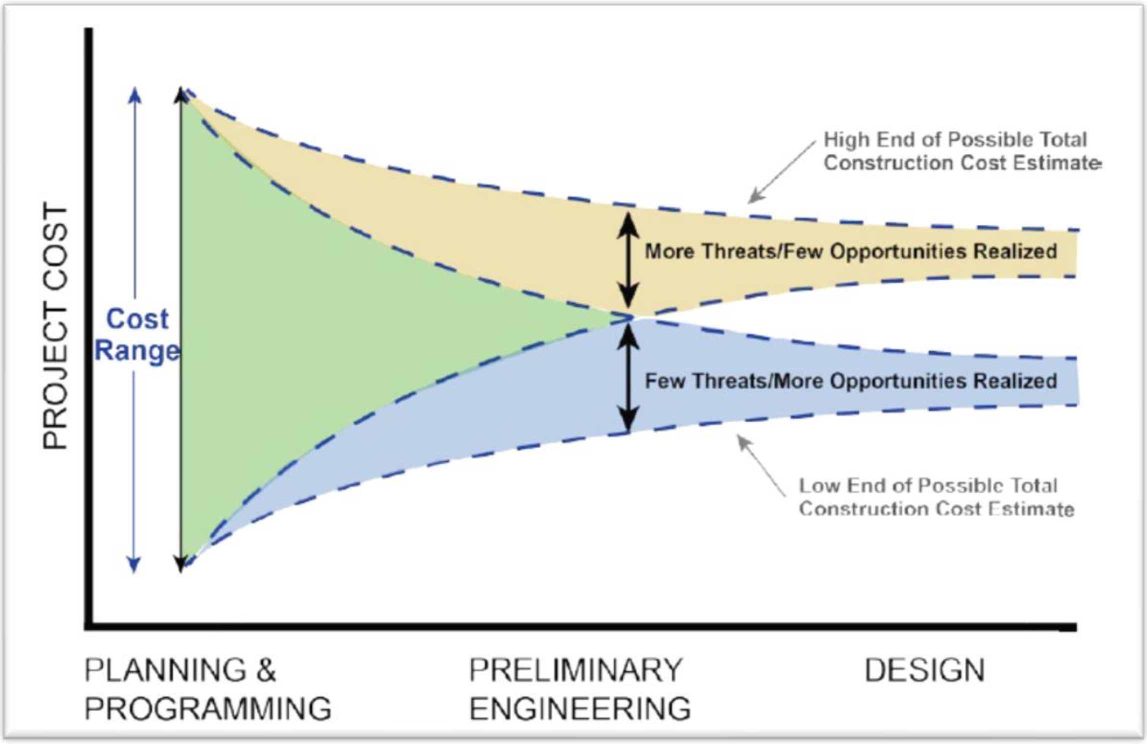


Figure 2.1 The impact of Risk Management on Project Cost [17]

2.1.9 Sources of risk

For owners or sponsors and even to contractors or subcontractors, unforeseen risks and unplanned may mean incurring losses that are not recoverable. There are no projects without risks throughout the project executing process, the project can be considered risky if the risks lead to the probability to:

- Over Budget
- Out of Scope
- Behind Schedule

However, further categorisation is possible, if they contribute to more allocate risk sources [18].

Table 2.1 Sources of risk to the client's business from construction projects [19]

No	Heading Change and uncertainty due to
1	Political Government policy, public opinion, change in ideology, dogma, legislation, disorder (war, terrorism, riots)
2	Environmental Contaminated land or pollution liability, nuisance (e.g., noise), permissions, public opinion, internal/corporate policy, environmental law or regulations or practice or 'impact' requirements
3	Planning Permission requirements, policy and practice, land use, socio-economic impacts, public opinion
4	Market Demand (forecasts), competition, obsolescence, customer satisfaction, fashion
5	Economic Treasury policy, taxation, cost inflation, interest rates, exchange rates
6	Financial Bankruptcy, margins, insurance, risk share
7	Natural Unforeseen ground conditions, weather, earthquake, fire or explosion, archaeological discovery
8	Project Definition, procurement strategy, performance requirements, standards, leadership, organization (maturity, commitment, competence and experience), planning and quality control, programmed, labor and resources, communications and culture
9	Technical Design adequacy, operational efficiency, reliability
10	Human Error, incompetence, ignorance, tiredness, communication ability, culture, work in the dark or at night
11	Criminal Lack of security, vandalism, theft, fraud, corruption
12	Safety Regulations (e.g., CDM, Health and Safety at Work), hazardous substances (COSHH), collisions collapse, flooding, fire and explosion

2.1.10 Characteristics of Risk

As a general concept each risk has attributes like:

Risk is always in the future and not yet occurred if it has occurred, so it is a certainty, not a risk. If a risk is realized, it is considered an issue. The risk has a reason. The reasons for the event or the condition to become a reality. Examples of causes include assumptions, project constraints, requirements, and other conditions. Moreover, the probability or likelihood of occurring is greater than 0 percent and less than 100 percent. Finally, an outcome is an impact, negative or positive on the project or the operation.

2.1.11 Risk Identification

Identifying the potential risks is the first step to being able to manage them and account for them within the cost estimate and schedule. And the individual's cause and effect can be determined. Table 2.2 below illustrate some causes and effect of risks.

Table 2.2 Causes, Risks, and Effects [18]

what	Definition	Examples
Causes	Definite events or sets of circumstances that exist in the project or its environment, and which give rise to uncertainty	• The need to use an unproven new technology. • The lack of skilled personnel. • The fact that the organization has never done a similar project before. • The lack of pertinent project information such as geotechnical, survey, or design development.
Effect	Unplanned variations from project objectives, either positive or negative, which would arise as a result of risks occurring.	• Early milestone completion. • Exceeding the authorized budget. • Failing to meet agreed quality targets.
Genuine risks	Uncertainties that, if they occur, affect the project objectives either negatively (threats) or positively (opportunities).	• The possibility that planned completion targets might not be met. • Escalation rates might fluctuate. • The chance that requirements may be misunderstood. • Geological conditions more favourable than assumed.

In summary, the organization is required to identify each specific external, internal and risk management context issue that could impact the organization, acquire and evaluate timely knowledge and information about them, evaluate the risks and opportunities that these context factors present and take appropriate actions to mitigate the risks and embrace the opportunities. All of this must be documented within the scope of the risk architecture, strategy, and protocols (RASP) [20],

2.1.12 Secondary risks and responses

A primary risk is a self-initiating source of risk, usually related directly to the initial list of project elements. A secondary risk arises because of a primary risk, or as a consequence of implementing a control or a treatment response. A secondary response is a response to a secondary risk. For example, in some circumstances a fire might be a primary risk, with water damage and structural collapse as associated secondary risks. Where possible, secondary risks and responses should be embedded in the primary response, as this often simplifies the subsequent analysis.

The use of scenarios provides one way of doing this. However, it is not always possible, nor is it always desirable, to embed secondary risks and responses.

This is the case particularly if the secondary risk or its associated responses may themselves have major consequences, or if they differ in significant ways from the initiating primary risks. The same risk and response description worksheets may be used for secondary risks and responses [20].

2.1.13 Risk Management Roles and Responsibilities

At some level, all Stakeholders influence the Risk Management process. However, not all Stakeholders will be involved in Risk Management Planning. The Project Manager is the person who is ultimately responsible for delivering the project.

However, the project Manager should seek advice and input from the Project Team and other Stakeholders when developing the plan, particularly for larger projects. While the team should seek to address risks at the lowest level possible, not all risks can effectively be addressed at the project team level, and some may need to be escalated to the district or even Department Leadership level [17]. The project team is responsible for:

- Bringing knowledge and experience to Risk Management.
- Ensuring the plan is followed.
- Helping with the planning process.
- Executing and carrying out the details of the plan.
- Monitoring, managing, reporting on, and resolving risks for which they are assigned ownership.

One method of emphasizing that the entire project team is responsible for risk management is to make risk a standard discussion item during project meetings. Risk owners should report on any changes in a risk's anticipated impact and/or probability and if a risk's response plan is progressing or is ineffective. Placing risk on the meeting agenda also allows team members the opportunity to mention new risks that should be added to the risk register and managed accordingly [17].

2.2 Risk register

A risk register is defined in the ISO Guide 73 as the ‘document used for recording risk management process for identified risks. The guide adds that the purpose of the risk register is to facilitate ownership and management of each risk.

The use of risk registers has become established practice for many risk managers. There are disadvantages associated with the use of risk registers, including the danger that the information recorded in the risk register will not be used in a dynamic way. The risk register could become a static record of risk status, rather than the risk action plan for the organization. Typically, the risk register will cover the significant risks facing the organization or the project [20].

It will record the results of the risk assessment related to the process, operation, location, business unit or project under consideration. The purpose of the risk register is to form an agreed record of the significant risks that have been identified. Also, the risk register will serve as a record of the control activities that are currently undertaken. It will also be a record of the additional actions that are proposed to improve the control of the particular risk, Risk registers can be compiled in several formats, depending on the type of risk assessment that is being recorded. Where quantification of exposure is required, then a simple risk register held as a document is unlikely to be enough. This is true of systems for recording operational risks, where quantification of risk exposure is required.

Table 2.3 Risk register format [20]

Risk index	Risk description	Overall scoring	Magnitude	Likelihood	Control
1	Water flood and the overflow affecting the all-life aspects for up to many days. Anticipate that most project will be stop or maybe get serious defects.	High	High	High	Police emergency plans and crises agency plans to Investigate weather forecast especially if the region lies in flood zone or got like such event before and make quick contact with the families of staff and notify the clients.
2	Storm-force winds affecting transport routes for up to six hours. Anticipate that most roads in the vicinity will be closed or restricted. Journey times will be extended and late deliveries probable.	Medium	Medium	Medium	Police emergency plans Highway Agency plans Investigate weather forecast Liaison with the families of staff Notification to customers
3	Serious traffic accident involving the transport of fuel/explosives. Anticipate fatalities and evacuation of 1 km radius, depending on substances involved. Potential for release of up to 30 tonnes of liquid fuel into local environment	Medium	High	Low	Police emergency plans Highway Agency plans Local authority emergency plan Company emergency response Liaison with the families of staff Notification to customers

Ideally in risk management, a risk prioritization process is followed in which those risks that pose the threat of great loss and have a great probability of occurrence are dealt with first, refer to the table below:

Table 2.4 Risk action and impact [19]

IMPACT	ACTIONS	ACTIONS	ACTIONS
MINOR	Accept Risks	Accept but monitor Risks	Manage and Monitor Risks
MODERATE	Risk is bearable to certain extent	Management effort worthwhile	Management effort required
SIGNIFICANT	Considerable Management Required	Must Manage and Monitor Risks	Extensive Management essential
likelihood	**Low**	**moderate**	**High**

The above table can be used to strategize in various situations. The two factors that govern the action required are the probability of occurrence and the impact of the risk. For example, in a condition where the impact is minor and the probability of occurrence is low, it is better to accept the risk without any interventions. In a condition where the likelihood is high, and the impact is significant, extensive management is required. This is how a certain priority can be established in dealing with the risk. Apart from this, typically most organizations follow a risk management cycle as shown in figure below:

Figure 2.2: The process of risk management [153]

According to this cycle there are five steps in the process of risk management. The first step is the identify risks, followed by assessing and analyse. The last step is measuring the impact and control.

The importance of risk register

The dynamic risk register is at the heart of a successful risk management initiative and A well-constructed considered. The risk register may become a static document that records the status of risk management activities at a moment in time.

The practical implications of this are that senior management may consider that attending a risk assessment workshop and producing a risk register fulfils their risk management obligations and no ongoing actions are required [20]. It is better to think of the risk register as a risk action plan that records the status of the organization with respect to risk management, but also provides a record of the critical controls that are in place, together with the details of any additional controls that need to be introduced. In producing such a risk action plan, the responsibility for undertaking the actions identified will be clearly established.

2.3 Risk Management Planning

Before implementing risk management process, providing and presenting the design of risk management is the most logical step [23]. Risk management planning is the process of making decision about the approach and method of conducting the activities of risk management in a project. In this stage, the level and the type of risk management is determined according to the risk and the importance of project for the organization, the needed resources for the activities of risk management, and according to the foundations of facing risks [22].

For example, a project with only one rudimentary design development requires a simpler structure than a project with a sophisticated design development and modern production techniques [23]. Besides keeping the risk management cycle in mind; before the final draft, an effective risk management plan may traverse through following:

- **Make a List:** Before starting or deciding on anything else it is important to make a list of potential risks.
- **Prioritize the Risks:** Arrange the risk in order of priority. Those that need to be dealt with first are listed first. Risks are prioritized on the basis of degree of impact and the likelihood of occurrence.
- **Developing and Action Plan:** Plans are designed to minimize the impact of the risk and to check the occurrence. In addition, an action plan in developed against each risk i.e., in event of occurrence how do we respond to the risk, who all will be responsible and what are the contingencies.
- **Human Resource Deployment:** Now people are deputed at specific points with specific roles. They work in tandem with the entire team and are specially deployed to undertake planned actions in case the anticipated risks come true. These actions are to be taken at specific points in time; a timeframe is necessary
- **Communication:** Finally, communication of the plan to stakeholders (both internal and external becomes necessary). Present the plan to those who are supposed to make key interventions. Explain the timeframes and the actions and the responsibilities.

2.4 Risk Management Information System (RMIS)

The RMIS (risk management information system),it is the software system that manage the risk action and add value and allows us to manage stakeholders more efficiently, effective resource use central risk function manages risk management as opposed to one-to-one chasing, it is helps embed Risk management at directorate level, moves forward in alignment with funding strategic and maturity model, solving version control issues and reduce cycle time and Allows automated reporting to senior management.

The RMIS, are record the information held in the risk register. This will help with risk understanding and communication. In some organizations, the risk register is given the status of a controlled document to be used by internal audit as one of the key reference documents for undertaking an audit of risk management activities. The information set out in the risk register should be very carefully considered and prepared clearly.

In addition, the risks set out in the register need to be precisely defined so that the cause, source, event, magnitude and impact of any risk event can be clearly identified. Also, the existing control activities, together with any additional controls that are proposed, must be described in precise terms and accurately recorded. Risk control activities should be described in enough detail for the controls to be auditable. A project risk register must be a very dynamic document. A project risk register example is provided in table below.

Table 2.5 Project risk register [23]

Risk index	Risk description	Overall scoring	Magnitude	Likelihood	Action to be taken
1	Project resources inadequate with insufficient staff to support project.	High	High	High	Project management team established with support from other staff departments, including HR and Finance.
2	Project management arrangements unable to deliver project	Medium	Medium	Medium	Clear project management structure in place, with executive team established to oversee project. Smaller project team runs project on day-to-day basis with expert support, as required. Clear links between various management functions to ensure co-ordinated approach.
3	Project not co-ordinated with other developments in organization.	Medium	High	Low	Project management team also oversees related projects with cross-representation on other groups

When a strategic decision must be taken at management level, the risk assessment of that strategy should be attached to the scope. This risk assessment could include both the risks of undertaking the strategy and an analysis of the risks associated with not undertaking the proposed strategy. Finally, a risk register should be attached to a business plan as a record of the risks that could impact the achievement of that plan [20].

Simple examples of the risks that could result in the business plan not being achieved are set out in this illustration. For example, a cosmetic and health centre project may wish to record risks to provide a special material in construction in the risk register. There could be concerns regarding the delay of the project, so that the board will require a detailed evaluation of the resource risks related to:

● legal compliance.

● supply of the goods on time.

Table 2.6: Risk register attached to a business plan [23]

Risk index	The circumstances	Overall scoring	Magnitude	Likelihood	Action and assurance
1	Upgrade costs of the job	High	High	High	Provision has been made in reserves and any additional costs will be met from existing budgets.
2	Claims of the Overtime	Medium	Medium	Medium	Heads of department should enforce the rules concerning overtime payments as a result of job upgrades
3	Loss funding grant	Medium	High	Low	Negotiations are in hand and final settlement figure should soon be notified.

When considering the resource as an example here, the level of control that is required will be evaluated, together with responsibility for managing the project. The centre management will also make sure that existing monitor and additionally are described in a way that will ensure that achievement of the controls can be fully audited. The management will hope to see the risk register on at least a quarterly basis, and more iterative if significant changes occur. This will ensure that the register still updated and a dynamic document. It will also ensure the necessary event are taken and reported to the management.

2.5 The Risk Assessment

It is necessary to determine the probability of it occurring the risk and the impact on the project if it does occur. Risk analysis determines contingency reserved to place in the cost estimate to account for these possible of impacts. Assigning values for the probability and impact relies on the expert's judgment on the risk meeting analysis. There are two approaches to risk assessment qualitative and quantitative analysis.

2.5.1 Qualitative analysis

Qualitative analysis is a research methodology that aims to understand and explain the subjective experiences, attitudes, beliefs, and behaviours of individuals or groups through non-numerical data collection and interpretation. The phrase qualitative methodology refers in the broadest sense to research that produces descriptive data people's own written or spoken words and observable behaviour, the qualitative methodology, like quantitative methodology, is more than a set of data-gathering techniques [161]. It is a way of approaching the empirical world. It is particularly useful when discovering complex phenomena that cannot be measured easily or quantified. The most important side of qualitative analysis in research is the ability to provide detailed aspects of social phenomena and human behaviours. It makes researchers explore issues from the perspective of those who experience them, leading to a deeper understanding of the complexities of the topic research [162].

In qualitative studies, researchers follow a flexible research design [163]. The studies begin with only vaguely formulated research questions. However, when starting the researcher doesn't know for sure what to look for or what specific questions to ask until spent some time in a setting. As learn about a setting and how participants view their experiences, then it can make decisions regarding additional data to collect based on what already learned. Of course, qualitative researchers operate within theoretical frameworks. The interest in social meanings directs the attention to some aspects of how people think and act in a setting and not to others. Within a broad theoretical framework, the goal of qualitative research is to make sure the theory fits the data and not vice versa [164]. For the qualitative researcher, all perspectives are worthy of study. The goal of qualitative research is to examine how things look from different vantage points. The overview of qualitative research methods includes two main components: data collection techniques and data analysis techniques.

- **Data Collection Techniques**

The most commonly used qualitative research methods are interviews, focus groups, and observation. The interviews are used to collect data from individuals conducted one-on-one between the researcher and the participant, and the researcher asks open-ended questions to explore the participant's experiences, opinions, and attitudes. Focus Groups involve gathering a small group of people with similar characteristics or experiences to discuss a particular topic. Such groups are particularly useful when exploring group dynamics and the shared experiences and attitudes of a particular group. The researcher asks open-ended questions to encourage discussion and gather insights. The observation method involves people in their natural environment and recording their behaviour and interactions. This method is particularly useful when studying non-verbal communication and social interactions [162].

One of the applications of qualitative analysis is a relative measure of risk using descriptive categories such as low, medium, high; or on a scale from 1 to 10. This type of analysis is typically used to rank or prioritize the risks relative to one another, the priority of risks is determined according to the risk occurrence probability and its impact on the project objectives; so that the management will observe the more serious risks and the risky dimensions of the project will be noticed in the following steps [22].

Finally, the qualitative analysis of risk serves three functions; Prioritise risks according to probability & impact Identify the main areas of risk exposure. Improve understanding of project risks Projects are exposed to all sorts of risks and it's impractical for project managers to deal with them. In many cases, the resources spent to mitigate a risk outweigh the risk itself. As such, one of the main goals of qualitative risk analysis is to prioritize risks upon their probability and impact. This allows project managers to focus on devising treatments for the most significant risks. Using this method also gives project managers a better idea of the main areas of risk exposure and to achieve this categorizing their risk sources is important. This is crucial when it comes to prioritizing risk areas and treatment schedules.

Qualitative risk analysis can also improve a project manager's understanding of risks. This helps devise more effective risk treatments and contingency budgeting for future projects. Project managers discover much more than risk probability and consequences. They also discover trigger conditions, assumptions and affected project elements. All of this helps build up a better picture for future projects [165]. The matrix of risk probability and impact below is represented to be used to assist the workshop participants with estimating the risk and its results [23].

Table 2.7: Risk probability and impact matrix [23]

A common event that probably occurs 6 times a year or more				**15-25 Impermissible**		
It probably occurs once or twice a year				**6-12 Permissible within Limitation**		
It may occur or has already occurred				**1-5 permissible**		
Probability Factor	High probability (5)	5	10	15	20	25
	Probable (4)	4	8	12	16	20
	Possible (3)	3	6	9	12	15
	Improbable (2)	2	4	6	8	10
	High Unlikely (1)	1	2	3	4	5
		Trivial/Little (1)	Insignificant/Secondary (2)	Important/Significant (3)	Serious/Great (4)	Major/primary (5)
		Impact Factor				

2.5.2 Quantitative analysis

Quantitative analyses use estimated percentage probabilities and dollar amounts (or time amounts when analysing schedule risks) to develop a specific contingency amount to carry in the estimate to account for each risk [10]. This analysis is carried out for risks of high priority in qualitative assessment, which can significantly affect the project objectives.

Moreover, quantitative risk assessment analyses these risks quantitatively and allows the possibility of deciding under conditions of uncertainty [24]. Quantitative risk analysis uses verifiable data to analyse the effects of risk in terms of cost overruns, scope creep, resource consumption, and schedule delays.

By ranking severity in broader terms, qualitative risk analysis is useful for gauging probability and prioritizing risk in a way that’s easy for non-project control people to understand. This can help with stakeholder buy-in by offering a small sample of the wider risk landscape.

The quantitative approach to risk analysis is better for managing the risk of modern projects. It provides a better means of understanding how risk and uncertainty affect project outcomes. But that doesn't mean that qualitative risk analysis is useless.

Quantitative risk analysis relies on accurate statistical data to produce actionable insights the kind that hasn't been historically available. So instead, project managers used a more subjective, qualitative approach to risk management. So, while it might be quicker, the best way to get the most robust risk analysis is through quantitative and it allows:

- Quantify outcomes
- Set achievable cost and scheduling targets
- Clear up uncertainty surrounding the results of initial qualitative analysis
- Assess the probability of successfully achieving these goals [165].

2.6 Risk Treatment

The purpose of risk treatment is to determine what will be done in response to the risks that have been identified, in order to reduce the overall risk exposure. Unless action is taken, the risk identification and assessment process has been wasted. Risk treatment converts the earlier analyses into substantive actions to reduce risks. The primary inputs to this step are:

- The lists of risks and their agreed priorities from the previous step; and
- Current project plans and budgets.
- Developing detailed Risk Action Plans [10].

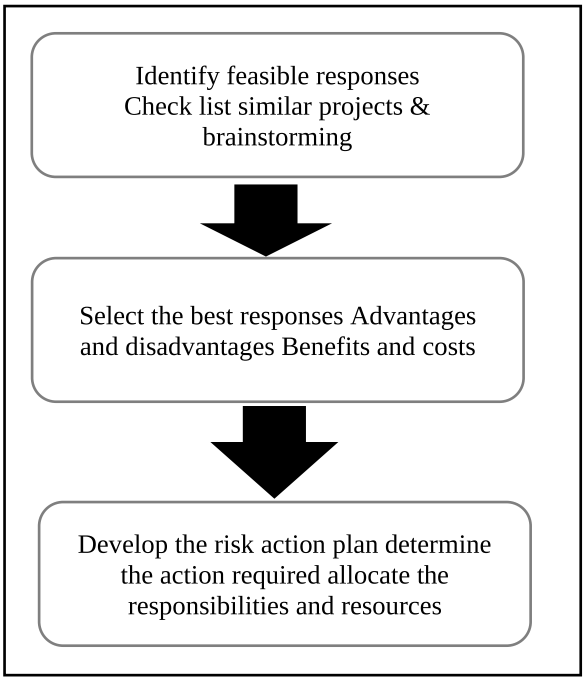


Figure 2.3: The process of selecting and developing effective risk treatments involves Overview of risk treatment [10]

Risk treatment strategies

The Risk Action Plans developed and implemented to treat an identified risk will depend on the nature of the project and the nature of the risk. They cannot be specified in detail in guidelines like these. However, some general suggestions can be provided.

During the response identification and assessment process, it is often helpful to think about responses in terms of broad risk management strategies:

- Risk prevention (including risk avoidance);
- Impact mitigation
- Risk sharing
- Insurance; and
- Risk retention

In practice, these categories overlap to some extent. Nevertheless, they provide a useful framework for thinking about how to deal with risks. These categories are tactical responses. The organization should determine how they should be combined into its overall strategy, according to the extent to which it is prepared to accept or tolerate risk. Policy decisions such as this must be made at senior levels in the organization, not left to individual managers [10].

2.7 Risk response in dealing with of threats and opportunity

Risk response planning no doubt is an integral aspect of risk treatment. The planning covers discusses and evaluates inputs like risk register, risk profiles and cause control matrix. Strategies are formulated and documented in this stage. The following seven different strategies are discussed upon the treats or the opportunities risks, in addition, the risk can be a real opportunity and good event to the project throughout the life cycle.

2.7.1 Accepting the opportunity/ threats risks

This strategy is the best when the risk is low threats. But there must be a due plan for the same such as determining when the project will be exposed to the risk and making small adjustments accordingly. A risk that is acceptable can be considered passive since no action at all is taken upon the same.

This strategy may be appropriate for low-priority opportunities, and it may also be adopted where it is not possible or cost-effective to address an opportunity in any other way. Acceptance can be either active or passive.

The most common active acceptance strategy is to establish a contingency reserve, including amounts of time, money, or resources to take advantage of the opportunity if occurs. Passive acceptance involves no proactive action apart from periodic review of the opportunity to ensure that it does not change significantly [15].

2.7.2 Escalate the opportunity or threats

This strategy based on the authority of the project manager to deal with the case wither it can threat, or opportunity/threat are appropriate when the project team or the project sponsor agrees that an opportunity is outside the scope of the project. Escalated opportunities/threats are managed at the portfolio level or program level, or other relevant part of the organization, and not on the project level.

2.7.3 Exploit

Priority opportunities where the organization wants to ensure that the opportunity is realized. This strategy seeks to capture the benefit associated with an opportunity by ensuring that it definitely happens, for example, the organization responses may get an offer to buy very cheaply and high-quality equipment and machines to the project saving a lot instead of the renting and consider it a great opportunity should the organization exploiting it.

2.7.4 Share

The idea is to share the expecting benefit with another partner either inside the stakeholder group or to present a new partner. It is extremely important to choose the proper partner or owner to invest the opportunity in order to don’t losing the chance. The opportunities can be cost, time or performance benefits. For an example of sharing joint ventures.

2.7.5 Enhance

When the opportunity to make a better action in the project can be by add some activities or resources in order to make a better performance or less time this action is known as enhancing. Mostly the project managers seek tools and techniques to enhance their action during the lifecycle.

2.7.6 Avoiding Risk

It can be an expected event depends on the expertise of the team skills, the expert judgment or the lesson learned register to record what can be as a risk event in the current project and make the required action to follow and avoid it before it occurs.

2.7.7 Mitigating Risk

The mitigating of risk is a process to decrease the effect of the risk when it is occurring. The reserved or contingency plan must include the allowance to cover this type of risk.in the meantime makes a controlling on the related process or event that can be effect by this risk.

2.7.8 Transferring Risk

It is an ideal method to eliminate the project future risks by transfer the risk event to another receiver or owner. For example, subcontractor, insurance policy.

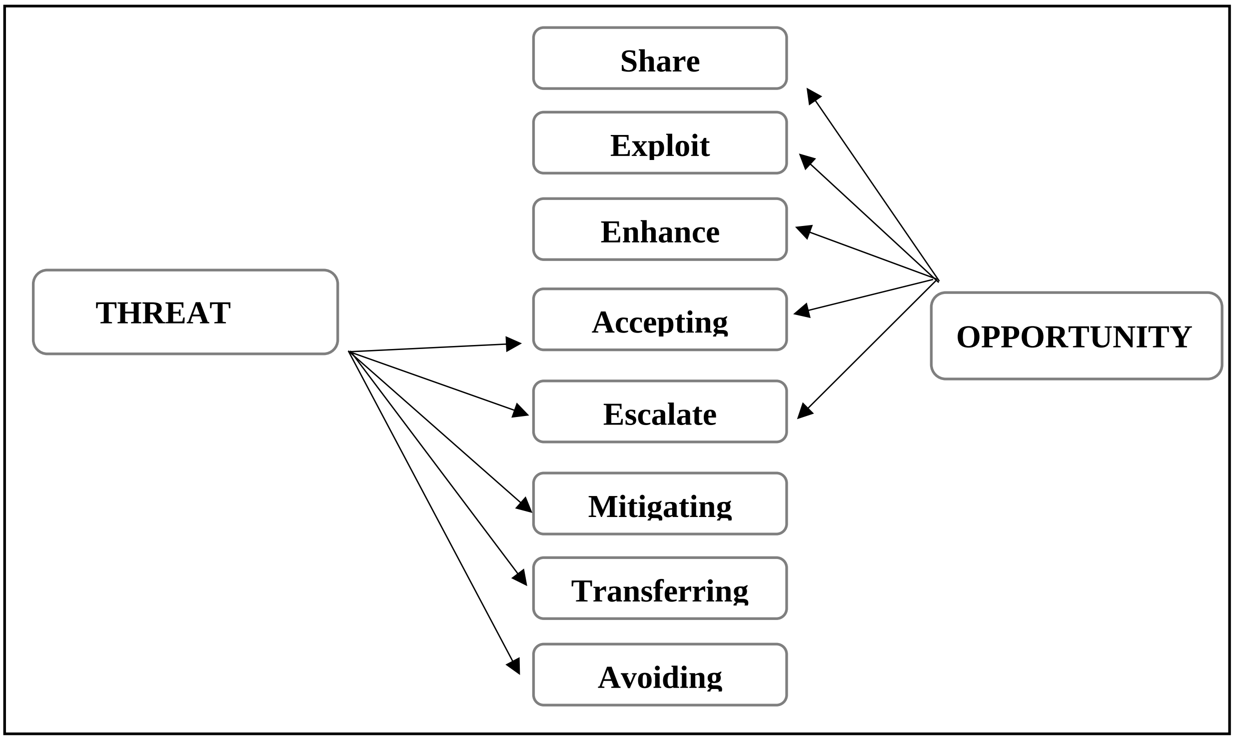


Figure 2.4: Risk response in case of threats and opportunity [154]

2.8 Risk Monitoring and Control

Monitoring and Controlling risks by Executing and evaluating the effectiveness of risks responses plans, it is essential to notice well-defined schedules are crucial to the success of this task [9]. The project team must attempt to consider the risk monitoring and control as the inseparable part of management process. The objectives of this stage incorporate monitoring the identified risks and the new ones, making sure of the accurate reaction occurrence and reviewing their effectiveness, and monitoring the risk changes in all the stages of project[23].Throughout the process of planning and conducting the project, we must adhere to a series of principles such as cancelling or reducing secret precautions; the precautionary time and cost must be considered in the uncertain activities; reducing the required precautions through effective use of risk response must be considered. The potential extra cost must be controlled through avoidance, reduction, or transfer of separate risks in the project. Concerning the pressure of need for communication between the project employees, one of the most important problems of projects is the lack of communication.

Risk assessment is not able to solve this problem and it can be merely solved through the improvement of communication among the members of team project in all the sections of the project.

Regarding identifying and responding to all risks throughout the phases of the project, risks can occur in all the phases of the project from the initial design to the final performance. It is necessary to identify and manage all the risks that can exist potentially in the project [25].

2.9 Lean risk management

2.9.1 Introduction in Lean

As the introduction of the lean understanding, the beginning was from the end of the 1970s, a confusingly long array of new approaches to production management has emerged, two-approach are competitive, JIT (Just in Time), TQM (Total Quality Management), time-based competition, value-based management, process redesign, lean production, world-class manufacturing, concurrent engineering. After closer analysis, it transpires that the above-mentioned management approaches have a common core but view this from different angles. This common core is made up of a conceptualization of production or operations in general; the angle is determined by the design and control principles emphasized by any approach.

For example, JIT stresses the elimination of wait times whereas TQM aimed to eliminate errors and the rework, but both apply this angle to a flow of work, material or data information. The new production philosophy, regardless of what term is used to name it (world-class manufacturing, lean production), is the emerging mainstream approach practiced, at least partially, by major manufacturing companies in America, Europe, and Japan. Thus, a new production philosophy is emerging through the generalization of these partial approaches, as has been suggested recently by various authors [26,27]. The new philosophy has already had a profound impact on such industries as car manufacturing and electronics.

The conceptual and theoretical aspects of the new production philosophy are the least understood. However, without conceptual and theoretical understanding the application of methods is bound to remain inefficient and haphazard. In Figure 1, an attempt for a consolidation of the new production philosophy is presented [28]. The application of the approach has also diffused to fields like customized production, services, administration, and product development.

The conception of the new production philosophy evolved through three stages: It was viewed as a tool (like Kanban and quality circles), as a manufacturing method (like JIT) and as a general management philosophy (referred to, for example, as world-class manufacturing or lean production).

2.9.2 Lean Thinking

Lean Thinking provides a- way to specify value, line up value-creating actions in the best sequence, conduct these activities without interruption whenever someone requests them, and perform them more and more effectively. Lean Thinking provides a way to do more and more with less and less— less human effort, less equipment, less time, and less space—while coming closer and closer to providing customers with exactly what they want. Lean Thinking also provides a way to make work more satisfying by providing immediate feedback on efforts to convert waste into value [29].

The five principles of Lean Thinking are:

- Specify value from the standpoint of the end customer by product family.
- Identify all the steps in the value stream for each product family, eliminating whenever possible those steps that do not create value.
- Make the value-creating steps occur in tight sequence so the product will flow smoothly toward the customer.
- As flow is introduced, let customers pull value from the next upstream activity.
- As value is specified, value streams are identified, wasted steps are removed, and flow and pull are introduced, repeat this process again and continue it until a state of perfection is reached in which perfect value is created with no waste [30].
- Lean manufacturing implementation in organization helps in proper structuring of processes and maximum waste reduction which leads to improved performance [30].

2.9.3 Lean Six Sigma

Six Sigma inhibits the process variation on priority by imparting the entire process toward the mean [30].

The six-sigma management philosophy can be summarized as:

- Measurement — Specify quality and value in the eyes of customers, and measure customer requirement and process performance;
- Transparency — Management decision is based on data and fact, as well as understanding the gap through benchmarking;
- Optimization — Adopting a proactive approach to optimizing processes;
- Systemizing — An inherent focus to eliminate waste and variation throughout the entire value chain, and then standardizing the process;

- Consistency — Involve and empower all employees to cooperate without boundaries, and the existence of a mechanism to ensure the implementation and operation of optimized processes;
- Quality Culture — Continuous improvement in pursuit of perfection [31].

When Six Sigma tools were implemented in an organization, it resulted in improved organizational performance rather than other quality approaches [32]. Lean Six Sigma is a philosophy comprising a number of organizational factors that are critical to the successful deployment in which the senior Six Sigma facilitators adopt the Six Sigma methodology referred to as define-measure-analyse-improve-control (DMAIC) phases, and within each phase, various statistical and lean tools are selected as appropriate [33].

Hybrid development of the two practices is their fusion, which is termed as Lean Six Sigma (LSS). While understanding the requirement to deliver business value to the consumer in a rapidly changing environment and considering the demands of end-users into account, the integration of Lean development and Six Sigma seems to be a promising endeavour and has received increasing attention in recent years [34].

2.9.3 Lean Construction

In the broader construction industry, lean construction is employed as a continuous process of improving construction projects through the elimination or reduction of waste and to meet or even exceed client requirements [31].

The application of lean construction in the construction industry contributes to eliminating non-value-adding activities in the construction process while increasing value-adding activities [35]. Conceptually, lean construction is rooted in lean operations in the field of operations management.

The objective of lean production is to decrease the waste inherent in converting physical inputs into outputs in the production process. Similarly, lean construction is, therefore, a way to design production systems in building construction to minimize waste of materials, time, and effort to generate the maximum possible value. Thus, the value generated through the application of lean construction occurs during the project delivery process and is often referred to as lean project delivery [37]. Lean project delivery pursues three goals. First, transform inputs to outputs and make the production realized more efficiently.

Second, to ensure the flow of materials, composed of transformation, inspection, moving, and waiting, to eliminate waste (or non-value adding activities). Third, to create value for the client by fulfilling his/her objectives. These goals are complementary and should be integrated into implementing lean construction [36].

2.10 The Summary of the Chapter

Project Risk Management firstly aimed to discover and identify and manage risks that are not addressed by other project management processes. The fact is the risks have the potential to creeping the scope from the project plan or not meet the project objectives or deliverables, therefore, the effectiveness of project risk management is directly related to project success. The figure below introduces the risk management process and illustrate the risk road map in conventional way, the current study will present the new added value by lean in this map.

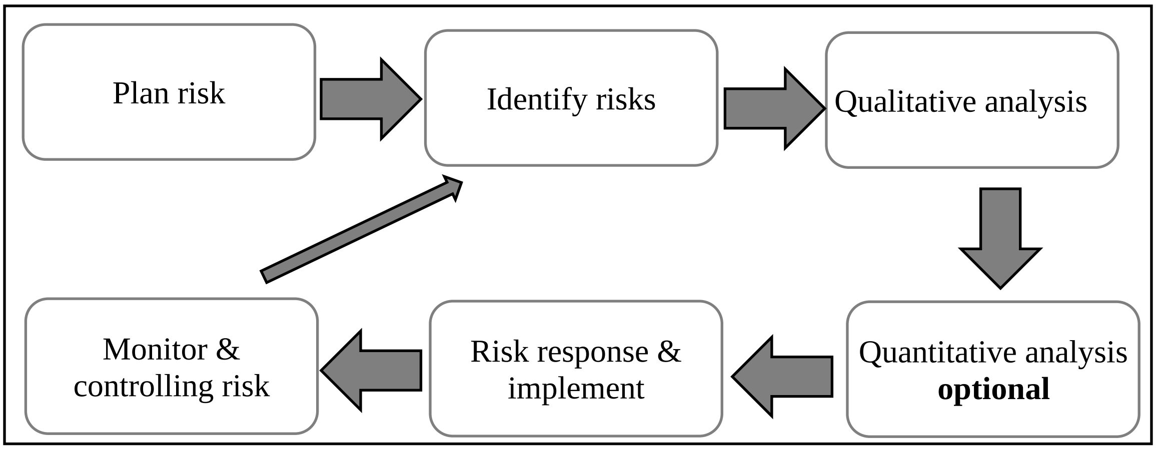


Figure 2.5: Illustrate the risk management road map [154]

Risk treatment includes determining what will be done in response to the risks that have been identified, for the purpose of reducing the potential risk exposure. Any controls and plans in place before the risk management process began are augmented with Risk Action Plans to deal with risks before they arise and contingency plans with which to recover if the risk comes to pass. At the end of successful risk treatment planning, the detailed ideas will have been developed and documented about the best ways of dealing with each major risk, and risk action plans will have been formulated for putting the responses into effect.

Moreover, to these project-specific plans, risk treatment might also include alteration of the base plans of the organization.

Finally, the team record the risks identified and treatment process and action in the lessons learned register after each treatment and the ongoing risks record in issue log register to transfer it to the operation manager later.

2.11 The Focus Area

The research will focus on the Iraq construction sites for many reasons, first of all, Iraq has many metal resources, and it can be a good environment to see important projects going well without delay if discovering and treating the most important causes of delay, secondly, it can be a good example in Asia to follow as a guide to cross the common risk factors.

Therefore, the risk factors in Asia will be searched first because of the great similarity between the environment of Iraq and most of the countries of the Middle East in terms of the economic, political, and climate environment, as well as project management. This, in turn, helps to increase the area of field research on risks, and chapter four will be devoted to that. The methodology used to achieve the research goals, will detailed in the next chapter.

3 The Methodology of research

3.1 Introduction

This chapter discusses the methodology adopted for the present study and an overview of the concept methodological the researcher used for studying risk management in Iraq, by studying the current situation in Iraqi construction sites, this is empowered by the literature review issued by Iraqi researchers during the last 5-6, and to discover more uncertain (risks) the researcher review Asian literature issued last 5-6 years which will help the researcher to select project risks in Iraqi. The thesis also presents the interviews with experts, the targeted population, the samples used, the analysis and evaluation of the survey, and the questionnaire to achieve the goal study and produce the risk management model to help organize the risk management of Iraqi construction projects.

3.2 Study procedures

As noted earlier in chapter one, the main outcome of this study is to develop a model for introducing risk management in construction companies in Iraq. One of the critical areas to consider is the kind of method that is adopted. For this reason, the methodology adopted in this study is in five phases complementary to each other which are as follows:

- First phase which presents different sources of information;
- Second phase which presents different sources of information;
- Third phase which presents survey by interviews and development of questionnaire;
- Fourth phase which presents data collections, statistical processing and measurement of validity and reliability questionnaire phase.
- Fifth phase which presents lean risk processioning on the current case and RMM and conclusion;

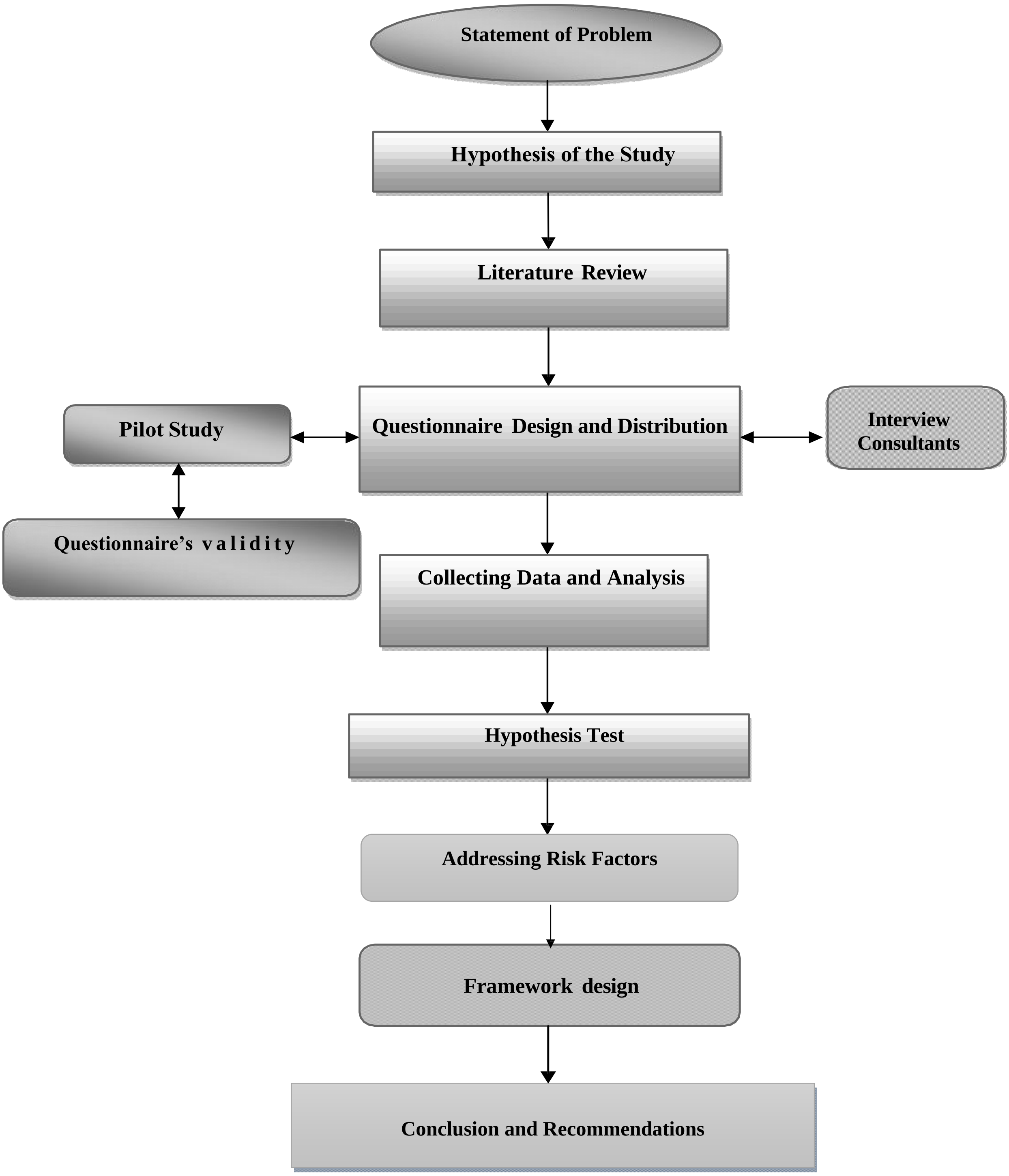


Figure3.1: Summary of methodology used in this research

3.3 Research Approach:

Selecting a research method is a critical important decision the researcher needs to study the approaches to know which of them will satisfy the objectives of the study, and will fit with the information available and with the information needed. There are many approaches in research methods, such as the quantitative and qualitative methods, and the deductive and inductive methods and both are related to each other.

Induction thinking is usually described as “moving from the specific to the general” which means going from observation to pattern the tentative and ends with theory. Deduction is “beginning with general and ending with the specific “which is assumed to be the other way around, beginning with theory going to the hypothesis then to observation, and ending with confirmation. In addition, qualitative and quantitative research are two of the main methods that have advantages and disadvantages however, there are researches where one is more useful than the other, The Table below summarizes the main differences in both methods [166].

Table 3.1: Quantitative & Qualitative methods differences

Quantitative method	Qualitative method
Deductive	Inductive
Quantify variation	Describe variation
Seeks to confirm hypothesis	Seeks to explore Phenomena
Uses questionnaires, surveys	Uses interviews and focus groups
Numerical value results	Textual results
Closed-ended questions	Open-ended questions
Used to measure and predict to achieve final actions	Used to uncover thought and provide basis for decisions
Determines most effective price and most desirable product	Identifies needs and generates ideas and develops hypothesis
Describes characteristics of a population	Describes individual experience to understand group norms
Inflexible and brief	Flexible and detailed

The table shows, the Quantitative method is used to predict and measure to achieve the final course of action, while the qualitative is used to understand thoughts, opinions and construct a basis for decision-making, and for this research, the researcher used the qualitative method mainly and quantitative method when needed to help more in completing the picture. As the researcher is seeking answers to many questions while using a predefined set of procedures to answer them, so qualitative method is the most suitable method to be used in this research, as this method aims to understand the problem from the local population involved, in addition, it helps in understanding the beliefs, opinions and relationships of individuals in the field using personal observation and in-depth interviews with some focus groups, and as a result of this the researcher describes the variations and explains the relationships to explore the phenomena needed in construction project management.

3.4 First phase: Asian research (chapter 4)

Information on risks was gathered from the literature. The sources of the reviewed literature were desk reviewed of both published and material including internet, journals, articles and reports on risks in Asian construction projects. The purpose of this phase is to enhance the understanding of theoretical concepts and identify the risk in the Asian construction industry and also to give an overview of the study statement and helps to meet the objectives highlighted.

Figure 3.2: Illustrate one of the cost-overrun infrastructure projects in Mumbai [167]

3.5 Second phase: Iraqi research (Chapter 5)

Information on risks was gathered from the literature. The sources of the reviewed literature were desk reviewed of both published and material including Internet, journals, articles, and reports on risks in Iraqi construction projects. The purpose of this phase is to enhance the understanding of theoretical concepts and identify the risks in the Iraqi construction industry and also to give an overview of the study statement and help to meet the objectives highlighted.

Figure3.3: Illustrate one of construction site in Iraq [168].

The information gathered from these phases (1,2) helped guide the third phase: questionnaire development and data collection from key respondents.

3.6 Third phase: Strategy and Approach to Data Collection (Chapter 6)

The third phase of the study includes the method employed, the design of the instrument, and the data collection and sampling technique. The current study strategy in this phase studies achieved quantitative and qualitative approaches to reach the objectives and helps in the comparison and statistical collection of data. The approach to be adopted for collecting data in social science research includes an experimental, archival, case study, problem–solving, and survey.

This study was based on a survey (questionnaire) because it enabled the researcher to use smaller groups of people to make inferences about larger groups.

Interviews analysis:

One of the qualitative methods which is used to identify patterns is Thematic analysis, in this research thematic analysis was used to analyse the interviews conducted with project managers, here are the steps used to reach the final themes that emerged from the data itself:

- Data was collected from the interviews, project managers, and the researcher's notes and observations.
- The text collected was examined closely, and the related and similar categories were gathered together.
- At this stage themes were developed according to the categories gathered from data.
- Data was studied according to the themes developed, to re-examine the relations.
- Once the themes have been collected and the literature has been studied, the researcher formulated theme statements.

Research population

This research studies the construction work in the Iraqi construction sites, the questionnaire will develop and distributed to the target sample. That including the five elements' engineers, contractors, sub-contractors, investors, and designers.

Questionnaire development

The design of the questionnaire was based on two basic factors, the first of which was identifying groups of risks that were collected from research methods, which were classified into risk groups distributed into seven groups.

Through interviews with specialists, the total risks were reduced to 36 risks that were considered the most important in Iraqi construction sites, according to the opinion of the specialists identified in the Appendix.

To better focus on risks and challenge them more accurately, the risks were distributed into twelve groups instead of seven groups that included all the identified risk factors.

Secondly, the researcher adopted an experimental model that was distributed to 50 respondents as a test sample for the questionnaire, through which the evaluation of the questionnaire was determined, the Cronbach Alpha was calculated, and its validity was determined before it was approved and distributed to the target sample.

The questionnaire was designed to be tailored to the target sample and includes four basic demographic and technical axes.

3.7 Fourth phase: Data presentation, and statistical analysis (Chapter 7)

The way in this chapter follows steps to analyse data starting to represent the collection of data from the questionnaire and then using statistical package for social sciences (**SPSS) v 26** software and Microsoft office **Excel** to represent the information as tables and charts to understand the data. Moreover, the validity questionnaire and reliability of the current study and an in-depth analysis is presented to understand the risk factors which are critical in the implementation of the projects in the construction industry in Iraq.

After collecting and analysing data for all risk factors, which are classified into specific groups, the two research hypotheses are tested using a T-test. To know the correlation between risks, Spearman's Rank-Order Correlation is used to determine the correlation value, which is represented in the form of a risk correlation matrix between all the identified risk groups.

3.8 Fifth phase: Lean study, RMM and Summary (Chapters 8, 9 and 10)

In chapter eight, the lean management principle was used in this study to develop a method for dealing with risks in projects in the Iraqi construction sector. Lean management tools are represented in this chapter and, selecting one of the Lean Six Sigma approach FMEA method for analysing data.

In order to apply the FMEA method, the RPN must be calculated, which is a main measure for prioritizing risks, it consists of three values, the first of which is severity, occurrence, and detection, and will calculated by specific formulas.

Severity, Occurrence, calculated by specific formulas depending on the survey form while the Detection value calculated depends on the supplementary questionnaire.

This annex questionnaire to the experts to obtain their opinion about the extent to which these risks were discovered by the project management.

The Pareto analysis will be conducted to study the risks and ranking. After classifying the risks according to the Pareto Principle, the researcher will adopt a new methodology to deal with the risks that were discovered in the initial chapters, Chapters Four and Five, and which were evaluated in several stages in Chapters Six and Seven.

This methodology benefits from lean management to reduce the impact of these risks and avoid their occurrence as much as possible by using appropriate tools for each type of risk discovered in the initial planning stages of the project. All lean management tools will be presented in this chapter, choosing the appropriate tools for the detected risks, presenting their advantages, and the mechanism of use which was identified as an important output of this study.

Chapter nine observe the RMM

The design of a new model to deal with risks in Iraqi construction projects (RMM), which is the main objective of the research.

The methodology developed by the researcher includes achieving the final goal of the research and the important output for risk management in the construction project. After completing all the requirements for completing the risk model, its steps will be drawn in the form of an arrow chart to manage the activities required to be managed by the project manager.

Chapter ten the Summary

The Summary of the research will be presented in this chapter, mentioning the details of the work carried out by the researcher to achieve the goals and prove the research hypotheses. Recommendations, lessons learned, and future research will be explained.

To start the theses research as above methodology; the next chapter (4) will focus on the Asian research of the most important causes of risk factors and what is the effect on the construction business and starting in Asia helps to discover the risk factors wider and can be effective in the Iraq projects.

4 The Asian construction projects and causes of delay and cost overruns

4.1 Asian construction

In general, Construction is fundamental to Asia's economy. Industry statistics project that construction spending grew from 36% of the global market in 2005 to 46% in 2020 the percent is not the same in the individual calculations in same of Asia countries, in India, for example, the construction industry is a main contributor to the GDP, employing 33 million people and impacting 250 related industries such as cement, coal and technology [38].

China used more cement than the United States (US) did during the whole of the 20th century in the three years between 2011 and 2013[39].

Singapore employs 326,000 foreign construction workers from across Asia in the construction industry, accounting for about a third of the one million work permit holders engaged in manual labor in the city-state of five and a half million inhabitants.

Booming real estate markets in Ho Chi Minh City, Yangon, and Phnom Penh, have resulted in massive evictions and expanding concerns over land grabbing [40,41,42].

In the Middle East, the Arab countries vary in the level of construction, where we note that the **United Arab Emirates** is considered an icon of urban movement, high-level construction and modern contemporary designs, not only in the Middle East but also in the world as well, while the **Kingdom of Saudi Arabia** is also considered to have potential and steps Important in the urban movement and the construction industry in the region, especially the new vision it launched for the year 2030.

The Egyptian Arab Republic, through the projects launched by the government there, including infrastructure projects and investments in the construction sector, will help to overcome the most important economic problems and develop industrial capacity, especially the new administrative city and the projects of bridges, tunnels and huge residential complexes.

In Iraq, the construction industry has gone through different stages due to the political changes and wars that the country has gone through, where important projects and infrastructure such as bridges, water and sewage networks, and housing projects have been delayed, Iraqi Iranian war and the gulf war that followed, where projects are disrupted or cancelled, and even after the wars stopped, the projects stalled for many reasons and cost huge amounts of money more than planned.

It is important to know the most important reasons that impede important projects that serve citizens and the economy by diagnosing the causes and risks that accompany projects and that lead to their delay or increase in their cost than planned.

In this chapter, the study will search for these reasons in Asian and Middle Eastern countries, identify them, and know the extent of their impact on construction projects. The fifth chapter will be devoted to studying and discovering risks in construction projects in Iraq as a case study for this thesis.

The search for risk factors in Asia is critical because the work environment is similar in most Asian countries, including Iraq, and the research will help to identify most of the important risks that affect the progress of construction work to avoid them.

4.2 Risk Factors in Construction

The risk factor is a term used to name the causes that can be effect on the project plans and led to negative changes or also positive results. In order to handover a construction project successfully, it is so important to manage the risk in terms of time, cost and quality. Risks always exist in construction projects and often cause cost overrun or schedule delay.

The risk management is a process which consists of identification of risks factors, reassessment into tow type of analysis qualitatively and quantitatively, response with a suitable method for handling and control risks and monitoring.

4.3 The Asian construction risk research

Many of research in Asia discovered the most important factors that cause risks in construction business. The researchers have deferent opinions towards factors, some of them registered risks related to economic, and others related to management... etc. [43], categorized risks into six groups in accordance with the nature of the risks, i.e., management, financial, legal, market, policy and political, as well as technical risks [44].

Bent Flyvbjerga (2018) [45], defined the “cost overrun” as: Cost overrun is the amount by which actual cost exceeds estimated cost, with cost measured in the local currency, constant prices and against a consistent baseline. Through the current research of Asian construction projects in the last (6-5) years, many risks factors are registered and classified to six groups as shown in table 4.1 below:

Table 4.1: Illustrate the construction risks causes of cost overrun and time delay in Asian site [source: own study]

No	Causes of cost overrun and time delay
1	Lack of planning and management
2	Variation Works/Change order
3	Errors in Design or changes
4	Lack of scope clarity or changes to the projects' scope and cost
5	Improper project feasibility study or pre-initiation the project
6	Contractual Weakness
7	Transportation and logistic
8	Poor management
9	Safety in construction
10	Illness or death of workers
11	Terrorism and Sabotage
12	Delays in producing or approval of design documents by the client
13	Design and drawing flaws
14	Reworks due to poor quality or flaws in execution
15	Inadequate Site planning and management
16	Poor communication with client/Imprecise expectations
17	Low productivity of the workers (poor working conditions, low morale)
18	Delays due to Incompetence, or lack of experience of workers
19	Inaccurate quantity estimates or excess quantity during construction
20	Unforeseen ground conditions (lack of site investigation)
21	Inter-party conflicts
22	Financial problems of the client
23	Financial problems of the contractor
24	Delaying or refusing payments to contractors, subcontractors or workers
25	Complexity of construction projects
26	Poor communication between the parties
27	Lowest bidding procurement method
28	Delay in making decisions
29	Excessive bureaucracy
30	Insufficient geotechnical investigation
31	Time underestimation (inadequate time)
32	Working out unrealistic program of work
33	Faulty or incomplete information at the inception stage
34	Bad weather or climate conditions
35	Random events (e.g., accidents)
36	No access to required technology or obsolete construction methods
37	Labors’ strike and union activity

No	Causes of cost overrun and time delay
38	Insufficient number/lack of workers
39	Insufficient number/lack of qualified personnel
40	Insufficient number/lack of machines
41	Poor quality of machines and equipment breakdowns
42	Poor quality or damage of building materials
43	External economic factors (fluctuations of prices and interest rates, inflation, recession)
44	Delays in the delivery of materials
45	Inconsistencies and mistakes in contract documents
46	Delay in approving design documents by an inspector
47	Difficulties with obtaining a permit for the execution of construction works
48	land acquisition delays
49	Changes in the applicable law
50	Delays due to complex political situation

There are up to **30** publications have been presented in Appendix (A), and resources from (46-75) and the practical survey are made and locates the causes of delay and cost overruns, and can be classified into categories management, financial, legal, market, policy and political risks, technical risks, and seven category is the Safety and health issues in construction site this classification makes the study more specifically.

It has become necessary to discuss the causes of the occurrence of risks in construction sites and to know the extent of their impact on the course of the project. For this reason, the research discussed here the groups classified for the causes of risks and discussed them based on the opinion of researchers and specialists and the opinion of the researcher about the importance and impact of the risk on the project in terms of changes in cost and project schedule, as follows:

4.3.1 The Construction Management risks in Asian sites

One of the main roles undertaken by a project manager is manage the risks of a project. An effective and efficient risk management approach requires a proper and systematic methodology and knowledge with the experience [38].

As shown in the table below, the current research identifies the most important construction management risks in Asian sites, and from the point of view of Asian researchers and specialists the risks (R1, R2, R4, R6) have a high-risk impact on construction projects, the ranking of these factors comes from the opinions of consultants and engineers and investors.

From the **researcher's** point of view, the risk factors **(R1, R2, R4, R6)** are one of the sources that lead to cost overruns in projects, and the factors **(R7, R9)** represent poor communication and how management relates the parties to each other (stakeholders) at the optimal time.

Table 4.2: Illustrate the Construction Management risks in Asian sites [source: own study]

No	Management Causes of cost overrun and time delay	No of repetition in publications	Percentage %
R1	**Lack of planning and management**	29	**96%**
R2	**Lack of scope clarity or changes to the projects' scope and cost**	24	**80%**
R3	Improper project feasibility study or pre-initiation the project	21	70%
R4	**Poor management**	27	**90%**
R5	Delays in producing or approval of design documents by the client	23	76%
R6	**Inadequate Site planning and management**	25	**83%**
R7	**Poor communication with client/Imprecise expectations**	20	**66%**
R8	Complexity of construction projects	17	56%
R9	**Poor communication between the parties**	20	**66%**
R10	Delay in making decisions	23	76%
R11	Faulty or incomplete information at the inception stage	16	53%
R12	Delay in approving design documents by an inspector	15	50%

4.3.2 The Finical risks in Asian sites

The factors **R13, R14, R15,** and **R17** wear selected to represent the financial factors.

Many Asian studies conducted, like in **India** consider the financial issues, fluctuation of material prices, delay in progress payment, weakness of control of the cost, the currency prices differentiation [39].

Table 4.3: Illustrate the Finical risks in Asian construction sites [source: own study]

No	Finical Causes of cost overrun and time delay	No of repetition in publications	Percentage %
R13	**Inaccurate quantity estimates or excess quantity during construction**	22	**73%**
R14	**Financial problems of the client**	27	**90%**
R15	**Financial problems of the contractor**	25	**83%**
R16	Delaying or refusing payments to contractors, subcontractors or workers	20	66%
R17	**External economic factors (fluctuations of prices and interest rates, inflation, recession)**	22	**73%**

4.3.3 The Legal risks in Asian sites

The contract agreement must be reviewed by the law department carefully to save the rights of the parties, a lot of projects has big problems due to the weak points in agreements or not understanding the rules and conditions of penalties or the delay of project schedule and what is the proper penalties in case of the delay the project schedule, for that reason the factors (R18, R19) was selected.

Recently, the damages in many projects, especially the construction ones, have increased due to terrorist acts in the world and the Middle East in particular, which has significantly affected the performance of strategic projects and increased their cost, and stop them temporarily or in some cases inability to continue work and terminate the project. Therefore, it is important and necessary to take this factor (**R20**) into account in the study of risks.

J. Khattak and others (2019) [40], shows, the Owners consider it difficult as a severe risk to get permits from the government authorities to start projects, and the third-party delays, labor disputes, delayed dispute resolution are also legal construction risks in construction projects and should the contractor follow the local law and building code and ensure to follow the legal contractual compulsions so they can benefit from it.

The researcher's study opinion, the legal risks are crucial and there is no project that can start and hand over without considering the legal risks into risk plan and response to it through the project executing.

Table 4.4: Illustrate the Legal risks on the Asian construction sites [source: own study]

No	legal Causes of cost overrun and time delay	No of repetition in publications	Percentage %
R18	Contractual Weakness	23	76%
R19	Inconsistencies and mistakes in contract documents	19	63%
R20	Terrorism and Sabotage	14	46%
R21	Labors' strike and union activity	13	43%
R22	Difficulties with obtaining a permit for the execution of construction works	9	30%
R23	land acquisition delays	8	26%
R24	Changes in the applicable law	8	26%

4.3.4 The Market risks in Asian site

There is a tradition in most Middle Eastern countries in choosing the companies executing the work, which is to choose the companies with the lowest price.

From the **researcher's point of view**, this is not a correct step for several reasons, firstly the lower price may be at the expense of quality, secondly leading to the project being suspended due to the contractor's inability to continue after a short period of starting work because the repayment will be less than the contractor expenses to achieve the required quality according to the contract. Contractors should ensure and manage the proper resource planning and duration estimation to deliver the material and labours in adequate time to avoid delay [42]. The pre-prepared estimated price must be taken into consideration, and companies whose prices are higher or lower than the estimated price are not selected by a percentage of any more than 10% as a maximum to ensure that the schedule or quality is not modified and thus the project is completed at the contractual cost.

So, the factor **(R26)** is taken into account.

The procurement plan and methods of delivering materials and their arrival on time within the resource management plan must be reviewed periodically to ensure that construction materials are obtained on time, and this is considered one of the important factor **(R27)** in increasing the cost of projects, because of the project manager will be relying on other suppliers in the case of delays in the arrival of materials to the site, and this, in turn, will cost amounts that may be higher than the previous supplier's costs.

Table 4.5: Illustrate the Market risks on the Asian construction sites [source: own study]

No	Market Causes of cost overrun and time delay	No of repetition in publications	Percentage %
R25	Transportation and logistic	17	56%
R26	Lowest bidding procurement method	20	66%
R27	Delays in the delivery of materials	18	60%

4.3.5 The Policy and Politics risks in Asian sites

The Policy and Politics risks and their effect on Asian construction sites these factors **(R29, R30)** affect directly or indirectly in processes of the project and sometimes can be terminating the project especially if the country subjected to sudden attacks or participate in a war.

Table 4.6. Illustrate the Policy and Politics risks on the Asian construction sites [source: own study]

No	Policy and Politics Causes of cost overrun and time delay	No of repetition in publications	Percentage %
R28	Inter-Party conflicts	9	30%
R29	Excessive bureaucracy	10	33%
R30	Delays due to complex political situation	13	43%

Changes in government, agitation for change or dispute between parties are an example of the Political instability in such countries and can be happened.

Moreover, the failure to obtain the agreements in normal way and the officials demanding bribes or gifts are good representation of the Corruption [43].

4.3.6 The Technical risks in Asian sites

The technical matters are connected directly by the project activities and lead to either success the planned or many problems and this in final will translate to over cost and delay.

Variation or Change order, Errors in Design or changes in Design, and drawing flaws, and Reworks due to poor quality or flaws in execution, all these crucial factors are common and happened and still happing till today.

The current research considers the factors **(R31, R32, R33, R34)** and also the factors **(R36, R37, R39, R40, R41, R42, R43)** as technical sources of risks in the project and should calculate the risk impact of these factors in the pre-initial stages of the project.

Table 4.7: Illustrate the Technical risks on the Asian construction sites [source: own study]

No	Technical Causes of cost overrun and time delay	No of repetition in publications	Percentage %
R31	Variation Works/Change order	25	83%
R32	Errors in Design or changes	26	86%
R33	Design and drawing flaws	24	80%
R34	Reworks due to poor quality or flaws in execution	25	83%
R35	Unforeseen ground conditions (lack of site investigation)	15	50%
R36	Insufficient geotechnical investigation	19	63%
R37	Time underestimation (inadequate time)	24	80%
R38	No access to required technology or obsolete construction methods	16	53%
R39	Insufficient number/lack of workers	20	66%
R40	Insufficient number/lack of qualified personnel	23	76%
R41	Insufficient number/lack of machines	21	70%
R42	Poor quality of machines and equipment breakdowns	20	66%
R43	Poor quality or damage of building materials	22	73%

In fact, the labour mistakes, rework and idle times, labour shortage are mentioned in many projects and registered in risk register [44].

The construction technical risks are including all the above [45], and in researcher point view the all above are so important to study and assessment in current study.

4.3.7 The Safety and Health risks in Asian sites

Accidents, injuries, and even death that occur to workers on construction sites have become one of the main risks that must be taken care of by risk planners and project managers, and for this, it has become necessary to analyse the causes and sources that lead to the occurrence of these risks.

From the researcher's point of view must analyse and develop appropriate plans to respond to these risks, therefore, the factors **(R44, R45, R46, R47, R49, R50)** were taken into consideration in the current study.

Table 4.8: Illustrate the Safety and Health risks on the Asian construction sites [source: own study]

No	Safety and Health issues (Workers) Causes of cost overrun and time delay	No of repetition in publications	Percentage %
R44	Safety in construction	24	80%
R45	Illness or death of workers	18	60%
R46	Low productivity of the workers (poor working conditions, low morale)	24	80%
R47	Delays due to Incompetence, or lack of experience of workers	23	76%
R48	Working out an unrealistic program of work	17	56%
R49	Bad weather or climate conditions	19	63%
R50	Random events (e.g., accidents)	19	63%

In the Construction Management plan, it should be including the construction Health & Safety plan as a subsidiary plan together with contractor or the subcontractors' safety method statements. It should clearly show how the work will be supervised, how it will be monitored, and provide practical control measures (Project-templates link [41]).

The Safety Method Statement sets out safe systems of work for the operation of the risk and how to protect the workers' lives and avoid the expected risks for them.

4.4 The Summary of the Chapter

Through the previous research, the researcher was able to identify the most important risks in specific groups studied through published research in Asia, which the researcher relied on a statistical evaluation. Construction projects in Iraq.

The work environment and conditions in Iraq are very similar to most Asian countries, especially the Middle East countries, so the researcher adopted the most important risks in the previous research to be compared later with the risks of potential construction sites in Iraq.

Table 4.9: Illustrate the important risks on the Asian construction [source: own study]

No	Risk Category	RII	Percentage %
1	Construction Management	R1	96%
		R2	80%
		R4	90%
		R6	83%
		R7	66%
		R9	66%
2	Finical risks	R13	73%
		R14	90%
		R15	83%
		R17	73%
3	Legal risks	R18	76%
		R19	63%
		R20	46%
4	Market risks	R26	66%
		R27	60%
5	Policy and Politics	R29	33%
		R30	43%
6	Technical	R31	83%
		R32	86%
		R33	80%
		R34	83%
		R36	63%
		R37	80%
		R39	66%
		R40	76%
		R41	70%
		R42	66%
		R43	73%
7	Safety and health	R44	80%
		R45	60%
		R46	80%
		R47	76%
		R49	63%
		R50	63%

After studying each factor individually and taking into account the number of repeating risks in 30 publications (see Appendix (A) and references from (46-75)).

Based on this and the researcher’s opinion, a group of risks that directly affect the progress of construction work has been identified.

The **34** risks were distributed into 7 groups to specify the study and get more accurate results.

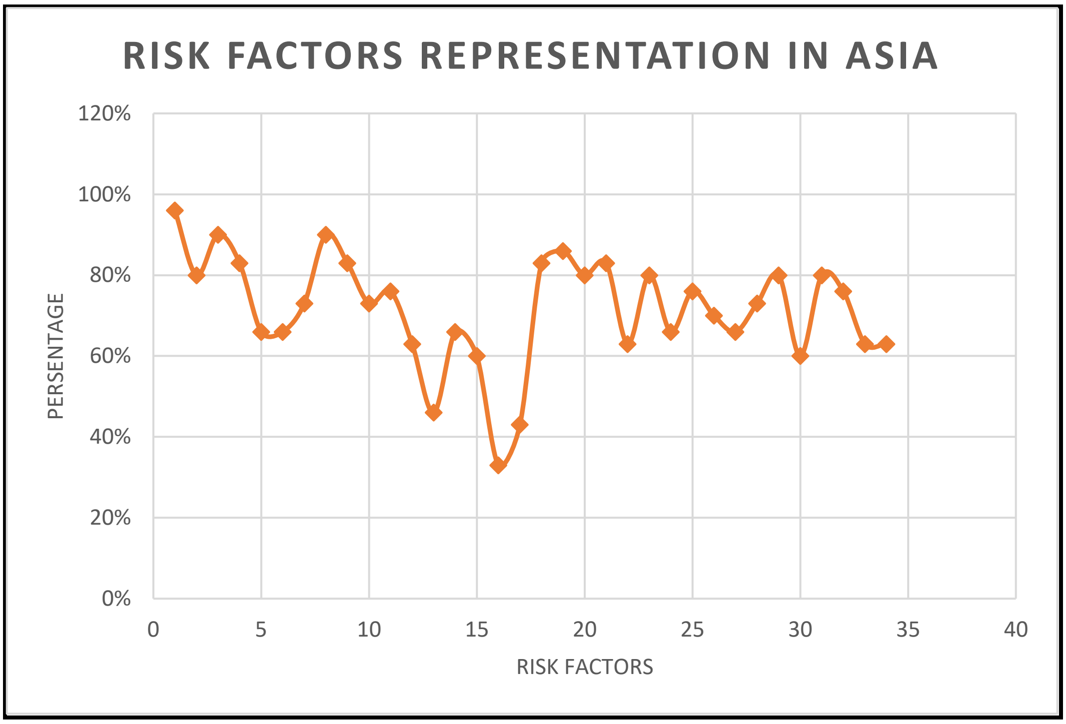


Figure 4.1: Illustrate the risk factors percentage in researches (Asia) [source: own study]

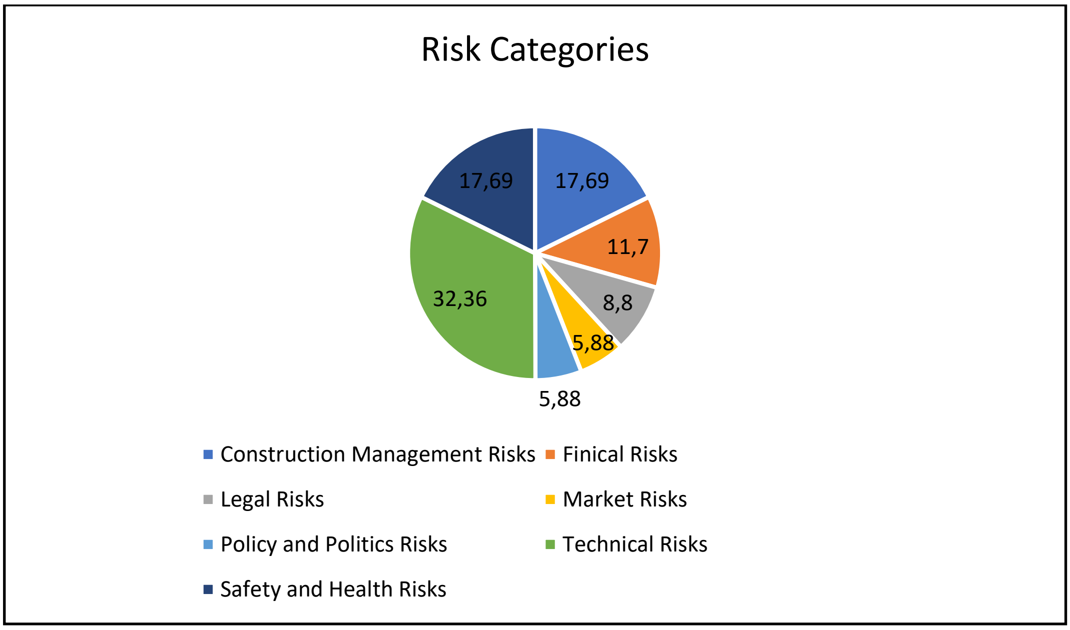


Figure 4.2: Illustrate the risk categories distribution in Asian constructions [source: own study]

5 Risk factors in Iraqi construction projects based on literature

5.1 Iraqi construction 1970 to present

Because of the political situations that the country went through, which created wars and economic crises that lasted fifty years ago and until recently had a clear impact on stopping, delaying, or cancelling many vital projects despite their importance and positive impact on the Iraqi economy, such as infrastructure projects, services, industries projects, and others.

Despite the country's substantial mineral resources (oil), it has not yet been well invested in achieving urban development and progress, as in the rest of the oil-rich countries in the Middle East.

The seventies of the last century was considered as a golden period for the country to implement many giant projects such as the international highway linking the Iraqi ports in the south with neighbouring countries (Syria and Jordan), bridges projects, electric power generation projects, starting projects to build schools, hospitals, and others.

Upon entering Iraq in the early eighties with the (Iraqi Iranian) war and the beginning of the nineties with the Gulf War and the subsequent wars in the face of terrorism, they directly caused delay the projects, poor funding, and loss of safety at work.

5.2 The Iraqi construction risk research

In the risk management of projects, a variety of tracks, including the precautionary track, which includes measures to avoid the emergence of the quality of the risks associated with the stage of the work of the project, there is also a corrective track, it includes an adjustment in the course of work at a stage of the work of the project not only results avoiding realized risks, but it also contributes to raising the level of work efficiency in the project.

The risks of projects may be in the form of defects, failures, or wastes in construction manufacturing that are discovered or occur during the execution of the project. Many of the research in Iraq discovered the most important factors that cause risks in construction projects.

Through the current research of Iraq construction projects, many risks factors are registered, analysed, and classified **in two ways:**

1. The Iraqi construction risk factors by literature reviews. (Current chapter)
2. The Iraqi construction risk factors by survey. (Chapters 6 & 7)

5.2.1 The Iraqi construction risk factors by literature reviews

Same as Asian method of review, there are **30** publications have been presented in Appendix B, and references from (76-105), and the review is made and locates the causes of delay and cost overruns, be classified into categories management, financial, legal, market, policy, and political risks, technical risks, and seventh category are the Safety and health issues in construction site this classification makes the study more specifically. Through the current research of Iraqi literature survey in the last (6-5) years, many risks factors are registered and classified into seven groups as below:

5.2.1.1 The Construction Management risks in Iraqi sites

Construction management seeks to recognize the potential risks related to construction projects and respond to those risks. Project risk management employs approaches that are likely to mitigate or prevent the effects of incidents [106]

By reviewing the research of Iraqi researchers, it was found that administrative risks have a significant impact on schedule management and cost overruns, as the planning factor was mentioned in 90% of the research, and the factors related to communication and decision-making at the right time were mentioned in a good percentage, meaning that they have an important impact on the progress of the project.

Most of the construction project managers in Iraq do not follow the pre-planned plans that were prepared at the stage before starting the implementation of the project, and this was recorded through the field tours of the researcher.

In addition, the researcher supports the Iraqi researchers, in that the communications between the administration, the contractors and the owner have an effective role in quickly reaching solutions to any emergency or risk that is not predetermined in advance (unknown risks).

Table 5.1: Illustrate the Construction Management risks in Iraqi sites [source: own study]

No	Management Causes of cost overrun and time delay	No of repetitions in publications	Percentage %
R1	Lack of planning and management	27	90%
R2	Lack of scope clarity or changes to the projects' scope and cost	17	56%
R3	Improper project feasibility study or pre-initiation the project	12	40%
R4	Poor management	21	70%
R5	Delays in producing or approval of design documents by the client	16	53%
R6	Inadequate Site planning and management	19	63%
R7	Poor communication with client/Imprecise expectations	17	56%
R8	Complexity of construction projects	14	46%
R9	Poor communication between the parties	17	56%
R10	Delay in making decisions	17	56%
R11	Faulty or incomplete information at the inception stage	11	36%
R12	Delay in approving design documents by an inspector	15	50%

5.2.1.2 The Finical risks in Iraqi construction sites

The collected questionnaires of one of Iraqi research showed the impact of the 'Finance Competence' related factors on the occurrence of the delay had the first arrangement with proportion 50% for other groups [107].

The factors **R14, R15, R16** and **R17** wear selected to represent the financial factors, it represented the most worried throughout the project going on, the weakness cash flow from the owner side and the financial ability of the contractor are causes many problems are affecting directly or indirectly the time of the project, so these factors are considered as main risks in current research (researcher point of view).

Table 5.2: Illustrate the Finical risks in Iraqi construction sites [source: own study]

No	Finical Causes of cost overrun and time delay	No of repetitions in publications	Percentage %
R13	Inaccurate quantity estimates or excess quantity during construction	13	43%
R14	Financial problems of the client	23	76%
R15	Financial problems of the contractor	22	73%
R16	Delaying or refusing payments to contractors, subcontractors or workers	19	63%
R17	External economic factors (fluctuations of prices and interest rates, inflation, recession)	25	83%

5.2.1.3 The Legal risks in Iraqi construction

By reviewing the published research of Iraqi researchers, it was found that **46%** of the research mentioned the importance of the factor of terrorism and sabotage, and this percentage is relatively small because this factor has a great impact and still poses a threat, even if in a lesser way than before.

The problem of terrorism took a lot of time and hindered many projects, especially the last ten years, and this in turn made project planners put the safety factor and the sudden stop of any project almost expected and at any time during the course of work, especially in projects with a long period of time, which in turn affects the cost and duration of the project and sometimes the quality.

In addition to other legal factors, the researcher supports that the weakness of legal obligations and contract terms or legal changes have a major role in the implementation of the project and the emergence of important risks.

Table 5.3: Illustrate the Legal risks on Iraqi construction sites [source: own study]

No	legal Causes of cost overrun and time delay	No of repetitions in publications	Percentage %
R18	Contractual Weakness	21	70%
R19	Inconsistencies and mistakes in contract documents	19	63%
R20	Terrorism and Sabotage	14	46%
R21	Labors' strike and union activity	11	36%
R22	Difficulties with obtaining a permit for the execution of construction works	9	30%
R23	land acquisition delays	10	33%
R24	Changes in the applicable law	20	66%

5.2.1.4 The Market risks in Iraqi construction

The studies revealed that the one of causes of market zone or category the delay related to the client is the low performance of the lowest bidder contractors in the Iraqi government tendering this leads to many problems related to quality and performance, and in the end the non-controlling on cost [108].

Table 5.4: Illustrate the Market risks on the Iraqi construction sites [source: own study]

No	Market Causes of cost overrun and time delay	No of repetitions in publications	Percentage %
R25	Transportation and logistic	17	56%
R26	Lowest bidding procurement method	14	46%
R27	Delays in the delivery of materials	20	66%

5.2.1.5 The Policy and Politics risks in Iraqi sites

The political turmoil in **Iraq** did not allow for any bold decisions to rebuild the country, especially after 2003.

Political stability and the reduction of routine procedures contribute significantly to advancing the wheel of reconstruction and not to those projects or to exposing them to frequent halts.

Table 5.5: Illustrate the Policy and Politics risks on the Iraqi construction sites [source: own study]

No	Policy and Politics Causes of cost overrun and time delay	No of repetitions in publications	Percentage %
R28	Inter-Party conflicts	11	36%
R29	Excessive bureaucracy	12	40%
R30	Delays due to complex political situation	18	60%

Bekr, Ali (2015,2019) [108,109] , concluded that the most effective delay factors affecting the time overrun in the public projects in Iraq were security measures, government change of regulations and bureaucracy, official and non-official holidays.

5.2.1.6 Technical risks in Iraqi construction

H. Rashid, (2016) [110] and others mentioned reducing the quality of work in order to meet the deadlines, importing materials that do not match the engineering specifications, lack of understanding of the drawings and specifications, errors in design, or changes and variation work/change order, are technical common risks in Iraqi in construction sites from the researchers and current research point of view.

Table 5.6: Illustrate the Technical risks on the Iraqi construction sites [source: own study]

No	Technical Causes of cost overrun and time delay	No of repetitions in publications	Percentage %
R31	Variation Works/Change order	21	70%
R32	Errors in Design or changes	24	80%
R33	Design and drawing flaws	21	70%
R34	Reworks due to poor quality or flaws in execution	16	53%
R35	Unforeseen ground conditions (lack of site investigation)	16	53%
R36	Insufficient geotechnical investigation	10	33%
R37	Time underestimation (inadequate time)	17	56%
R38	No access to required technology or obsolete construction methods	10	33%
R39	Insufficient number/lack of workers	15	50%
R40	Insufficient number/lack of qualified personnel	15	50%
R41	Insufficient number/lack of machines	12	40%
R42	Poor quality of machines and equipment breakdowns	11	36%
R43	Poor quality or damage of building materials	16	53%

5.2.1.7 The Safety and Health risks in Iraqi sites

All the works must be compelled to have their own precautions the supported plans for safety and health. The placement manager ought to produce secure operational surroundings for laborers. If any accident happens throughout the tactic, not only the schedule area units risked but other units will be got losses like cost.

Meanwhile, the site manager produces and implements security and health decisions to assure the health of workers and the safety of the activity moreover Inspections and direction are necessary also [111]. Therefore, enough money is supplied to create a positive labors safe environment.

Table 5.7: Illustrate the Safety and Health risks on the Iraqi construction sites [source: own study]

No	Safety and Health issues (Workers) Causes of cost overrun and time delay	No of repetitions in publications	Percentage %
R44	Safety in construction	15	50%
R45	Illness or death of workers	13	43%
R46	Low productivity of the workers (poor working conditions, low morale)	13	43%
R47	Delays due to Incompetence, or lack of experience of workers	18	60%
R48	Working out an unrealistic program of work	10	33%
R49	Bad weather or climate conditions	18	60%
R50	Random events (e.g., accidents)	19	63%

From the researcher's point of view analyse and develop appropriate plans to respond to these risks, therefore, the factors (**R44, R45, R46, R47, R49, R50**) were taken into consideration in the current study.

In **Iraq** also such as the other Asian sites, Accidents, injuries, and even death that occur to workers on construction sites have become one of the main risks that must be taken care of by risk planners and project managers and taken into accounts on the safety plans as a subsidiary plan from the risk management plan.

Table 5.8: Illustrate the important risks on the Iraqi construction [source: own study]

No	Risk Category	RII	Percentage %
1	Construction Management	R1	90%
		R2	56%
		R4	70%
		R6	63%
		R7	56%
		R9	56%
		R10	56%
2	Finical risks	R14	76%
		R15	73%
		R16	63%
		R17	83%
3	Legal risks	R18	70%
		R19	63%
		R20	46%
		R24	66%
4	Market risks	R25	56%
		R26	46%
		R27	66%
5	Policy and Politics	R29	40%
		R30	60%
6	Technical	R31	70%
		R32	80%
		R33	70%
		R34	53%
		R35	53%
		R37	56%
		R39	50%
		R40	50%
		R43	53%
7	Safety and health	R44	50%
		R45	43%
		R46	43%
		R47	60%
		R49	60%
		R50	63%

After studying each factor individually and taking into account the number of repeating risks in publication (30 publications see Appendix (B) and resources (76-105)). The R29 in Policy and Politics risks category in above table get lowest percentage of appearance in publications.

Based on this and the researcher’s opinion, a group of risks that directly affect the progress of construction work has been identified. The **35** risks were distributed into 7 groups to specify the study and get more accurate results.

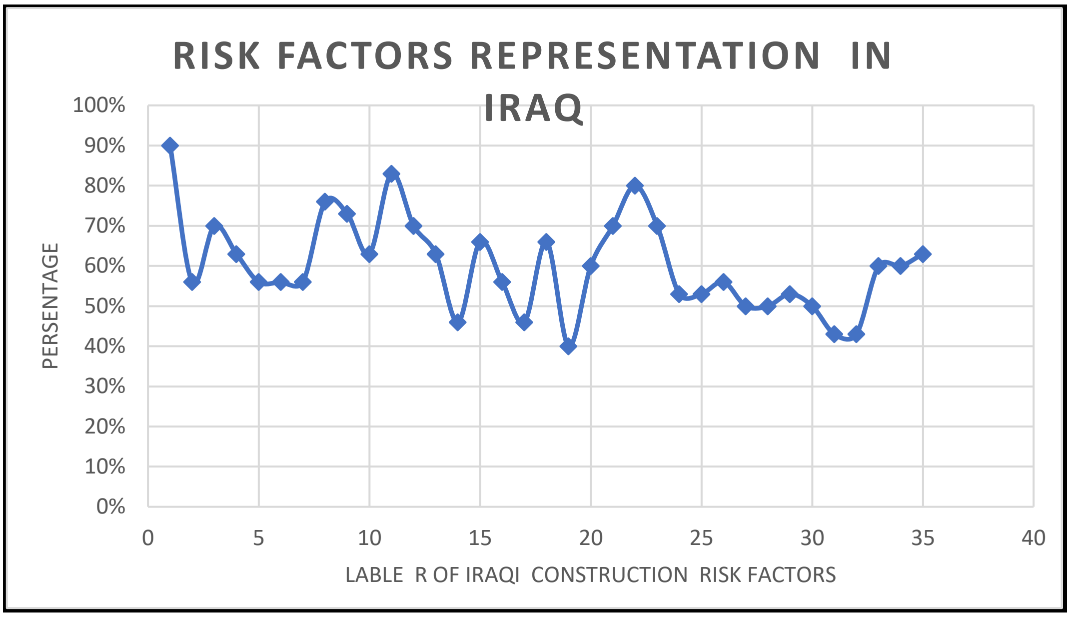


Figure 5.1: Illustrate the risk factors percentage in research (Iraq) [source: own study]

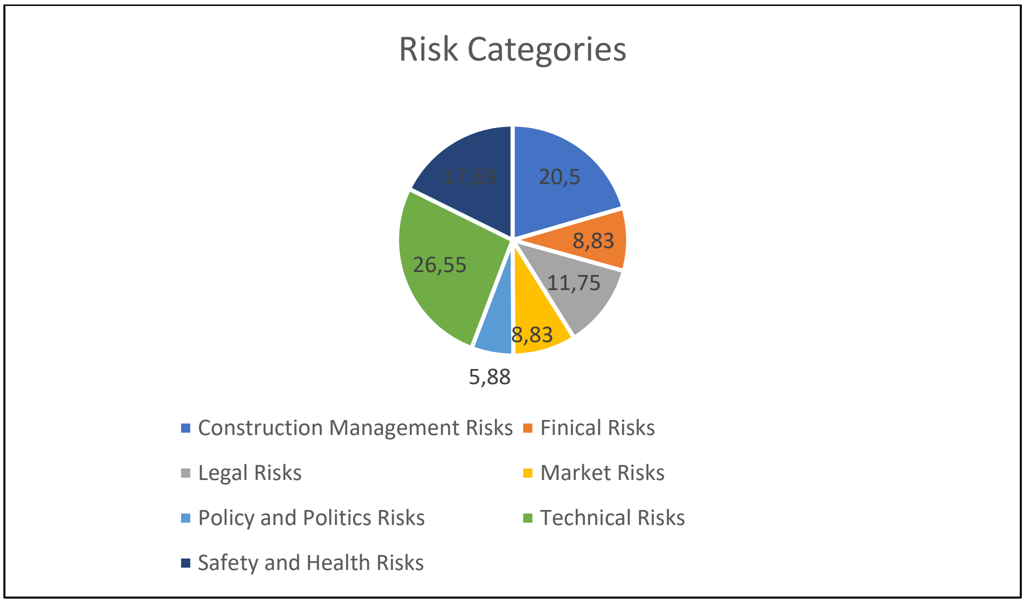


Figure 5.2: Illustrate the risk categories distribution in Iraqi constructions [source: own study]

5.4 The Summary of the Chapter

Through the previous research, the researcher was able to identify the most important risks in specific groups studied through published research in Iraq, which the researcher relied on a statistical evaluation. The previous research was carried out in two ways, the first is the research through the review of published research related to construction risks that occur in construction sites in Iraq, where many risks were discovered and amounted to up to **50** risks. Through the evaluation, the researcher found that **35** risks are the most important and distributed among seven groups.

As for the risks that were identified in Chapter four, which are related to the Asian environment, they are very close to the risks that were discovered in the Iraqi sites, so the Asian study was so important in locating the risks and the range of similarity between the Iraqi and Asian sites in risks side.

The appropriate questionnaire will be made in the next chapter to assess and study the risks of paramount importance, as the researcher identified groups to complete the questionnaire for them.

6 The Questionnaire

6.1 Questionnaire Development

The questionnaire was designed based on an extensive review of risk literature from Asia and Iraqi construction sites, interviews with experts, and a study of the local construction industry with input, revision, and modifications by local experts. The data for this study was collected through questionnaires to,

- To identify present problems (risk factors in Iraqi construction) that affecting the implementation of the projects
- To evaluate risk factors in the construction sector in Iraq.
- To know how the precent of the effectiveness of the risks on project time and cost from the respondence point of view.
- To know if there are any risks are causes to appear another.
- To know how many times the risks are appear in projects in point of view of despondence.
- To know which the most effects risks on projects.
- To prove that the 36 factors are the most curial risks in Iraqi construction business; and
- Finally, help to develop a risk management model as input data to the lean approaches.

The Questionnaire was in four sections:

- Section one, two and three was developed to elicit information about the respondents.
- Section four was developed to address objectives above.

6.1.1 The Demographic Sections of the questionnaire (sections 1 to 3)

The three sections are identifying the demographic variables of the respondents, Gender, experience in construction industry, category of work specialist, Party (Investor, contractor, etc.....), Role (top management, middle management, etc..), Academic.

Also, it contained the important questions that classified the respondents into three groups depend on the local experience or international or the mix, and give the indication about how much the respondents have an experience with the risk management curriculum (risk management plan).

6.1.2 Section four of the questionnaire

In the previous chapters, the most important risks were defined and then presented to the experts, who in turn identified the most important risks, which would cause delay and increase the cost of the project.

The Iraqi construction risk factors by Survey

In order to collect more risk factors in construction sites in Iraq. The researcher used in the fieldwork multiple techniques: brainstorming technique, as well as interviewing many experts and consultants to determine the most important risk factors at the present time.

The first technique is divided into two parts of which is individual interviews to explain the main idea and objective of the study and then the second meeting will be a meeting of all individuals for a useful brainstorming session that will be of importance to the study.

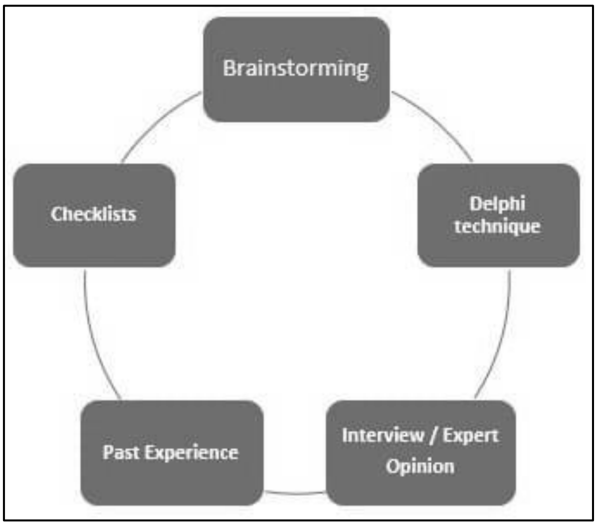


Figure 6.1: The five basic ways of risk identification [155]

The second technique is Interviews with experts to identify the most important reasons obtained by brainstorming sessions by meeting and listening to important experts in the field of construction and related specialties. The meeting was conducted with experts by visiting the site and making it a reality. The duration to achieve this took a long time because it is not easy to arrange an appointment with the experts and to make individual and group meetings. The experts were from several fields of construction projects are listed in Appendix (C).

-Statistical analysis of the data collecting

There are several kinds of rating scales that have been developed to measure attitudes directly like the Likert Scale, Delphi technique. The researcher has used the **Likert Scale** as a proper way.

Likert-type or frequency scales use fixed choice response formats and are designed to measure attitudes or opinions (Bowling, 1997; Burns, & Grove, 1997). In its final form, the Likert Scale is a five (or seven) point scale that is used to allow the individual to express how much they agree or disagree with a particular statement [112].

Likert (1932) developed the principle of measuring attitudes by asking people to respond to a series of statements about a topic, in terms of the extent to which they agree with them. The respondents are asked to indicate their agreement level with a given statement by using an ordinal scale, (Strongly agree /agree/don't know/disagree/ strongly disagree).

Table 6.2 below presents the field response of experts on the Likert scale. A five-point scale is used to allow the individual to express how much they agree or disagree with a particular statement, the interval is 0.8.

Table 6.1: Illustrate the level according to Likert scale quintet [75]

Level of agreement	Weight
Completely disagree	1.0-1.80
Disagree	1.81-2.60
Neutral	2.61-3.40
Agree	3.41-4.20
Completely agree	4.21-5.0

Statistical procedures for data have been completed, where the extent of the experts' approval and rejection of the reasons and their impact has been completed.

Table 6.2: Illustrate the most effective reasons by Likert Scale [75]

No	Description	Strongly agree (5.0-4.21)	Agree (4.20-3.41)	Don't know (3.40-2.61)	Disagree (2.60-1.81)	Strongly disagree (1.80-1.0)
1	Inadequate architecture design		×			
2	Inaccurate the estimation of the cost	×				
3	Misunderstanding of project objectives and the target		×			
4	Inadequate of the planning	×				
5	Poor of the funds for training and continuous development the engineers and administrators		×			
6	Poor of the funds for investigations, archiving, and data collection	×				

No	Description	Strongly agree (5.0-4.21)	Agree (4.20-3.41)	Don't know (3.40-2.61)	Disagree (2.60-1.81)	Strongly disagree (1.80-1.0)
7	The inability of the company to meet project requirements, because of the spec. of the projects			×		
8	unprofessional executive manager of the project			×		
9	unprofessional project teamwork	×				
10	The absence of an organizational structure for the enterprise	×				
11	The updating of the execution plan is not activated			×		
12	The contractual procedures for subcontracting are not adequate and not clear		×			
13	The performance evaluation ability is not appropriate					×
14	supervision committees are non-professional	×				
15	Arrange the site meetings weekly to discuss the updating	×				
16	The importance of communication between the designer and the team			×		
17	Delayed of the cash flows by owners	×				
18	Arbitrary and individually works		×			
19	The Bureaucracy in bidding tendering method			×		
20	The differences in the material prices					×

The above 20 reasons for the cost deflection of many projects should be noted in the implementation of project construction sites in Iraq assessed by experts, which already exist in the previous seven groups (see Chapter 5) except the factor R1 (Inadequate architecture design) will be added to the 35 risk factors list to be 36 risk factors will be studying in the questionnaire.

The risks were classified into seven categories in order to evaluate them. The researcher adopted in the design of the current questionnaire increasing the accuracy in identifying the most important risks. When presented to the respondents, by increasing the number of categories, the risks were distributed among twelve categories instead of seven, each category contains risk factors that threaten construction work in a proportion in terms of time and cost, to evaluate the current level of risk importance and respond in the construction sector in Iraq and each category contains group of risks (2-5) risk factors; as below:

1. Construction management risks (5 factors)
2. Communications risks (2 factors)
3. Financial risks (4 factors)
4. Legal risks (4 factors)
5. Market risk (3 factors)
6. Policy and Politics risks (2 factors)
7. Technical risks (3 factors)
8. Design risks (3 factors)
9. Human resources risks (2 factors)
10. Risks in mismanagement quality (2 factors)
11. Safety Risks (3 factors), and
12. Health Risks (3 factors)

The section four of the questionnaire also covers 4 questions for each category on cost and time affected by risks and the level of impact and the appearance of risks in projects.

Regarding developing a risk model that can be implemented in the construction industry in Iraq, the method adopted by Zhang (2000) [113], was chosen for the study. For this study, the method was pursued in two stages:

Stage 1: involves carrying out a review of literature in order to identify risk factors. Thirty-six (36) factors are selected from the expert's interviews to be the risk factors on the questionnaire.

Stage 2: involves ensuring that the instrument covers all the relevant spheres of risk and that the proposed survey instrument is well worded and understood. Thus, content validity is discussed in section 6.7. The final questionnaire had 36 factors for evaluation. In all, thirty-six factors in 12 categories, each category has 4 questions that were developed and measured within a five-point Likert scale; see Tables 6.3,6.4 below;

Table 6.3: illustrate Likert scale for questions 1 and 2 for each category [source: own study]

Item	Very strong	Quite strong	Moderate	Rather low	Very low
Scale	5	4	3	2	1

Table 6.4: illustrate Likert scale for questions 3 and 4 for each category [source: own study]

Item	Very high	High	Medium	Few	Very Few
Scale	10	9	8	7	6

The questionnaire was developed in both English and Arabic language as shown in Appendix **(D)**, to be understood by all respondents and to help in documenting this study.

6.2 Data Collection

Sampling Technique

In order to achieve the objectives, the sample population of the Study is determined: investors, managers, and engineers of construction companies in the main cities of Iraq were selected to be the population. The repetitive nature of the process of construction makes a choice suitable for the design and construction process, and the lessons learned to be incorporated into construction practices.

Five different involved parties are targeted in this study. The method adopted by Dís Dagbjartsdóttir S. (2012) [114].

The parties include investors, contractors, sub-contractors, engineers (consultants, site, supervisor), and designers. The parties were classified into three zones depending on the role of the projects; top management, middle management, and specialist.

- **Investors:**

The first party is represented by the Iraqi investors, which were registered by the National Investment Commission in Iraq in 2022 when the study was undertaken, and have valid registration. The investor's interesting fields of investment are building, roads, project management, water, and sewage. Therefore, the investors that are registered under other classes were neglected due to the limited practical and administrative experience of their companies in risk management implementation. There were 9000 Iraqi investors as shown in Table 6.3.

- **Contractors**

The second population is represented by the contractors, who have a valid registration on the IFC (Iraqi federation of contractors) recent list in its latest classification on 01 April 2022 for the following fields: building, water and wastewater, and roads.

Specifying the numbers of the contractors was not easy because each can have several classifications in different specializations. According to IFC 2022; the number of classified contractors in Iraq for all fields and all classifications from first to ten are 21000 contractors as shown in Table 6.3.

- **Engineers**

The third party is represented by the engineers, which were registered by the engineering association in Baghdad Iraq the headquarter in the year 2022 April when the study was undertaken, which have valid registration of consultant's engineers, active engineers, senior engineers, and others. in the following fields of civil engineering, and survey to be contained. There were 63122 engineers classified in Iraq in the above specializes and as shown in Table 6.3. and see Appendix (**E**) illustrate the list of Iraqi engineering association the total members.

- **Designers**

The fourth party is represented by the engineers, which were registered by the engineering association in Baghdad Iraq the headquarter in the year 2022 April when the study was undertaken, and they have valid registration fields of architect engineering. There were 7367 architecture engineers classified in Iraq in the above specialize and as shown in Table 6.5. and Appendix (**E**).

- **Sub-contractors**

The fifth population is represented by the sub-contractors, which are chosen randomly because there is no statistical to this population in exact written in contractors union or others in Iraq. Therefor the researcher considered a sample of 13000 sub-contractors to be a sampling of current questionnaire.

Table 6.5: Distribution of study population in Iraq by party [source: own study]

NO.	Population by party	No. population	percent
1	*Investors	9000	7.93 %
2	***Contractors	21000	18.50%
3	**Engineers	63122	55.61%
4	**Designers	7367	6.50%
5	Sub-contractors	13000	11.45%
Total		113489	100%

***. (Source: Iraqi Federation Union in Baghdad, April 2022)

**. (Source: Engineering Association in Baghdad, April 2022)

*. (National Investment Commission, Baghdad 2022)

6.3 The Sample Size Determination of the Study:

Sample size is defined as a subset of the total population. It was selected by random stratified method and chosen according to five type population (Investors, Contractors, Engineers, Designers and sub-contractors). As in the study conducted by Al- Tayeb (2008), to determine the minimum sample size, the formulas 6.1 and 6.2 shown below were used for unlimited population [115].

$$SS = \frac{Z^2 * P * (1-P)}{C^2} \quad \dots\dots\dots\dots\dots\dots\dots \ (6.1)$$

Where:

SS = sample size

Z =Value (for example: 1.96 for 95% confidence level)

P =Degree of variance between the elements of population (0.5)

C =Confidence interval (0.05) for 95 confidence level

Confidence Level = 95%, and Confidence Interval = 5, table 6.4 illustrate the Z-values for Confidence Intervals,

Table 6.6 Z-values for Confidence Intervals [116]

Confidence Level	Z Value
70%	1.036
75%	1.150
80%	1.282
85%	1.440
90%	1.645
95%	**1.960**
98%	2.326
99%	2.576
99.5%	2.807
99.9%	3.291
99.99%	3.891
99.999%	4.417

$SS = \frac{1.96^2 * 0.5 * (1-0.5)}{0.5^2} = 384.11 \approx 385$

And the formula below was used for correction for finite population [117].

Sample size for finite population:

$$SS_{finte} = \frac{ss}{1+\frac{ss-1}{pop}} \quad \ldots\ldots\ldots\ldots\ldots. (6.2)$$

Where: pop = population

$SS_{finte} = \frac{385}{1+\frac{385-1}{113489}} = 383.73 \approx 384$

6.4 Sample Selection for Present Study:

The samples were selected randomly with respect to the five populations. The five populations are Investors, Contractors, Engineers, Designers and sub-contractors, distribute in Iraq as in Table 6.7. Due to this formation, the stratified random sampling was used to identify the number needed for each population.

Table 6.7: Sample Distribution by Party [source: own study]

No	Party	No. Of Population	Percent	Sample Size For Each Party
1	Investors	9000	7.93 %	7.93 % * 384 = 30.45 ≈ 31
2	Contractors	21000	18.50%	71.05 ≈ 71
3	Engineers	63122	55.61%	213.57≈ 214
4	Designers	7367	6.50%	24.92≈25
5	sub-contractors	13000	11.45%	43.98≈44
	Sum	**113489**	**100 %**	**385**

Figure below shows the sample distribution for the five-party population needed to study.

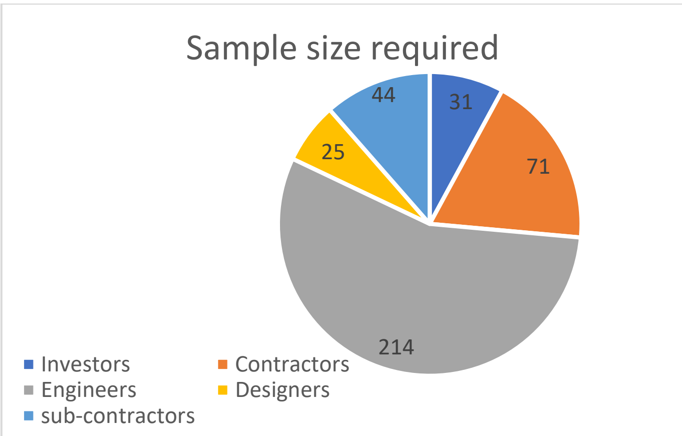


Figure 6.2: Sample Distribution by Party [source: own study]

The survey participants in this study are professors and lecturers in civil engineering faculties in Iraq, project managers, site and supervisor engineers, managers of construction companies, contractors, and sub-contractors who were participants in projects with local and foreign companies (worked in Iraq projects) may be used the curriculum of risk management in the projects they were in.

These respondents are selected because of the fact that they have the broadest exposure to construction projects, and are involved in various project phases including planning, design, and construction, also they have knowledge about the problem and subject area being studied. Indications are that their responses will minimize response errors.

6.5 Semi-Structured Interviews:

Application of semi-structured interviews with a number of representatives from different areas within the construction industry in order to collect information about their claims of the most serious problems that they are facing in the current situation. These interviews were selected following a study carried out by Latham in the United Kingdom for similar purposes [8].

6.6 Statistical Processing

To analyse data in this study, Statistical Package for Social Sciences (SPSS.26) and Microsoft Office Excel is used. Frequencies, percentages, means, and standard deviations are used to provide a comprehensive description of the acceptable degree of the study sample on the different questionnaire statements below and are calculated in the next chapter;

- Frequencies and percentages for analysis answers of the study sample regarding section one that gives information about the respondents.
- Means as one of the central tendency measures, and standard deviation as one of the dispersion measures to identify the extent of dispersion of respondents' answers in the various questionnaire statements.
- T-test of independent samples.

Measurement for validity was determined. Also, reliability was done using internal consistency method with the Cronbach coefficient, Alpha, as the relevant coefficient. The following sections explain how validity and reliability measurements are calculated.

6.7 Validity of Questionnaire by Pilot Study

Validity has a number of different aspects and assessment approaches. Pilot study and structure validity were used to evaluate instrument validity. A pilot study was made before collecting the final data to test the word of the questions, identify ambiguous questions, test the techniques which used to collect data and measure the effectiveness of standard invitation to respondents. Furthermore, it was used to improve the questionnaire, filling in gaps and determining the time required for completing the questionnaire.

In addition, it was important to ensure that all information received from engineers, contractors, sub-contractors, etc, were useful to achieve this study objectives.

Twelve questionnaires were sent and distributed to experts on the subject who have sufficient experience to amend and correct the questionnaire. The selected arbitrators list is attached in Appendix (**C**), who was selected as: an academician well versed in risks studies, project managers in a construction, civil and architecture engineering consultants.

6.8 Reliability of the Study

Reliability refers whether you get the same answer by using an instrument to measure more than once. For the purpose of this study internal consistency method is used in measuring reliability. The internal consistency of each factor was determined by examining each factor inter correlation and computing the Cronbach’s Alpha. The minimum advisable level is **0.755**. The proposed success factors whose calculated Cronbach’s α greater than the critical point of **0.70** [118], is said to be highly reliable and internally consistent. Table 6.9 shows the values of Cronbach's Alpha for the main factors and tables in the next chapter show the values of Cronbach's Alpha for all factors. Values of Cronbach's Alpha were in the range from **0.755** to **0.946**. This range is considered high; the result ensures the reliability of each field of the questionnaire. Cronbach's Alpha equals **0.973** for the entire questionnaire, which indicates an excellent reliability of the entire questionnaire.

Table 6.8: Reliability Statistics for Questions [source: own study]

Reliability Statistics	
Cronbach's Alpha	**No of Items**
0.973	**48**

Table 6.9: Cronbach Alpha for Each Category [source: own study]

No	Major Factor (Categories)	Alpha	Item (no of question for each category)
1	Construction mismanagement Risks	0.755	4
2	Communication Risks	0.833	4
3	Financial Risks	0.880	4
4	Legal Risks	0.908	4
5	Market Risks	0.905	4
6	Policy and Politics Risks	0.946	4
7	Technical Risks	0.873	4
8	Design Risks	0.903	4
9	Human Resources Risks	0.931	4
10	Risks in mismanagement quality	0.873	4
11	Safety Risks	0.928	4
12	Health Risks	0.939	4

6.9 Distribution of the Questionnaires and Collecting of Data:

The developed questionnaires were distributed using many ways and techniques as mentioned follows:

- Making an electronic questionnaire to be filled electronically through website link, some of the respondents were phoned to send their e-mails to send the link for them, all replies returned directly in the form of Excel sheet.
- Direct distribution by hand, but many of them do not have time for the meeting.
- Telephone calls to ask for meeting appointments, emails, WhatsApp groups or social media apps to send the link, some of the questionnaires were collected back on the same day while others were collected later from the respondents.

Data collection is a term used to describe a process of preparing and collecting data and the purpose of these processes is to obtain information to keep on record, make decisions about important issues, and pass the information on to others.

Out of the 600 questionnaires distributed to groups of civil and architecture engineers in construction projects and lecturers in civil engineering faculties, investors, and contractors, via social media, and emails, **512** were returned questionnaires fully accepted. The respondents who agreed to cooperate in filling the questionnaire are detailed in Table 6.10.

Table 6.10: Number of the Questionnaire Respondents [source: own study]

No	Respondent Type	Required size of the sample	No. Of Respondents	No. of Excluded Questionnaires	No. of Valid Questionnaire
1	Investors	31	57	0	57
2	Contractors	71	107	0	107
3	Engineers	214	336	0	336
4	Designers	25	77	0	77
5	sub-contractors	44	72	0	72
Sum		**384**	**512**	**0**	**512**

Sample Distribution Table

The following tables 6.11 to 6.17 represent the sample due to its main characteristics while figures based on them are presented in the next chapter.

Table 6.11: Sample Distribution due to its Gender characteristics [source: own study]

Gender		Frequency	Percent	Cumulative Percent
Valid	**female**	138	27.0	27.0
	male	374	73.0	100.0
	Total	**512**	**100.0**	

Table 6.12: Sample Distribution due to its Experience characteristics [source: own study]

Experience in construction industry		Frequency	Percent	Cumulative Percent
	1-5 years	132	25.8 %	25.8 %
	6-10 years	97	18.94 %	44.74%
	11-15 years	119	23.2 %	67.94%
	16-20 years	82	16.03 %	83.97%
	21 – and above	82	16.03 %	100%
	Total	**512**	**100.0**	

Table 6.13: Sample Distribution due to its Category of work characteristics [source: own study]

Category		Frequency	Percent	Cumulative Percent
Valid	**Private**	173	33.8	33.8
	Public	275	53.7	87.5
	Public & Private	64	12.5	100.0
	Total	**512**	**100.0**	

Table 6.14: Sample Distribution due to its Role in project characteristics [source: own study]

The Role		Frequency	Percent	Cumulative Percent
Valid	**Top Management**	149	29.1	29.1
	Middle Management	213	41.6	70.7
	Specialist	150	29.3	100.0
	Total	**512**	**100.0**	

Table 6.15: Sample Distribution due to its Academic characteristics [source: own study]

Academic		Frequency	Percent	Cumulative Percent
Valid	Bachelor's	240	46.9	46.9
	Master's	193	37.7	84.6
	PhD	79	15.4	100.0
	Total	512	100.0	

Table 6.16: Sample Distribution due to its location of work history characteristics [source: own study]

Location of work history		Frequency	Percent	Cumulative Percent
Valid	International	21	4.1	4.1
	Domestic& International	116	22.7	26.8
	Domestic	375	73.2	100.0
	Total	512	100.0	

Table 6.17: Distribution due to its experience with foreign companies' characteristics [source: own study]

Experience with foreign		Frequency	Percent	Cumulative Percent
Valid	No	270	52.7	52.7
	Yes	242	47.3	100.0
	Total	512	100.0	

6.10 The Summary of the Chapter

In the current chapter, the researcher conducted a design for the questionnaire and then presented it to experts for evaluation. The validity of the questionnaire is made by distributing a 50 samples questionnaire as a test for the reliability connected by computing Cronbach's Alpha which equals 0.973 for the entire questionnaire, which indicates excellent reliability of the whole questionnaire [118,119].

The size of the required target sample was also determined to be 385 respondents, and after distributing the questionnaire to the target audience, the researcher obtained 512 responses, which confirms the public's interest in the questionnaire because the topic is of great importance to the target audience, which confirms the quality of the specific sample that also participated in answering the questionnaire questions. The number of questions, which amounted to 48, were distributed to 12 risk groups.

The 512 answers to the questionnaire are considered almost double the number statistically required for the sample size (385), as it is considered a positive achievement for the study and will give a better indication of the respondents' answers, which will be analysed in the next chapter through the statistical study.

In the next chapter, the collected data from the questionnaire will be presented and a statically analysis will be conducted on it.

7 Data Presentation, Analysis and Discussion

7.1 Introduction

This chapter focuses on analysing the gathered data through interviews and questionnaires from respondents. The descriptive statistics of the data provide quantitative insight to this investigation and provides a valuable contribution to the aims of this study. The analyses presented here are based on data from the demographics of respondents' affiliations and the RM practices of respondent's analysis. Also, an in-depth analysis is presented to understand the risk factors which are critical in the implementation of the projects in the construction industry in Iraq. The results are structured to determine the risk level of the mentioned factors and their impact and level of importance on the cost and time of the project. The findings are presented in a statistical format such as charts and tables to enable examination and description of the pattern of the responses.

As research method to assess the risks factors collecting in deferent ways in previous chapters the questionnaire is adopted.

- The questionary goal
- The questionary components
- The results as output of questionnaire

7.2 Questionnaire sample characteristic analysis

Sample characteristics of the respondents and their employers are analysed.

The respondents' characteristics provide descriptive information on the individual respondents. Specifically, it provides information on the position, educational level, and their experience.

It provides information about the respondent's work, such as working in a domestic or international company, working outside of Iraq, or working with an international company that worked in Iraq.

This information is necessary to confirm the validity of the results obtained and to develop an understanding of the background respondent with accompanying experience in the construction sector in Iraq. The sample distribution will be presented with respect to the following questionnaire respondents' and characteristics.

7.2.1 Type of Organization:

The form of the questionnaire includes this question identifies the percentage of each type of target population: Investors, Contractors, Engineers (consultant, site, supervisor, etc.), Designers, and sub-contractors related to the overall respondents.

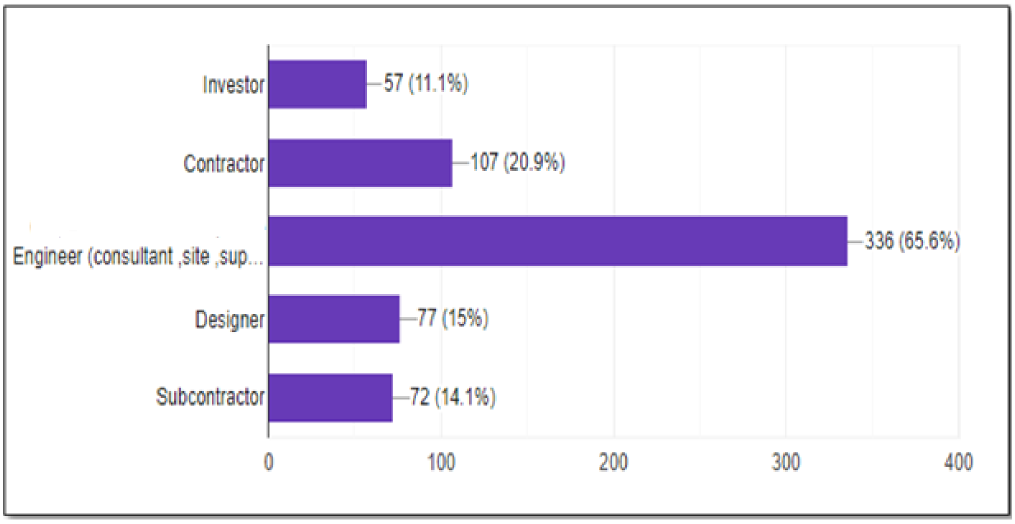


Figure 7.1: Distribution of respondent Based on type of party [source: own study]

In Figure 7.1, Respondents were asked to specify the type of work. 11.10 % of the respondents indicated that they work as investors, while 20.90 % indicated that they work as a contracting company, 65.60 % as site, consultant, or supervisor engineers, 15% as a designer in the shape of architecture or same affiliation in construction, and 14.10 % sub-contractors. These results show that respondents worked in more than one job title during work life (the questionnaire form allowed them to choose 2 choices as maximum).

The engineers were more widespread than the investors or others in Iraq.

7.2.2 Respondent Position:

It can be seen from Figure 7.2 that 41.6 % of the respondents were working in construction companies in middle management positions, 29.1 % in top management, and 29.3 % of them were specialists. This is an indication that the questionnaire respondents were key persons in their companies.

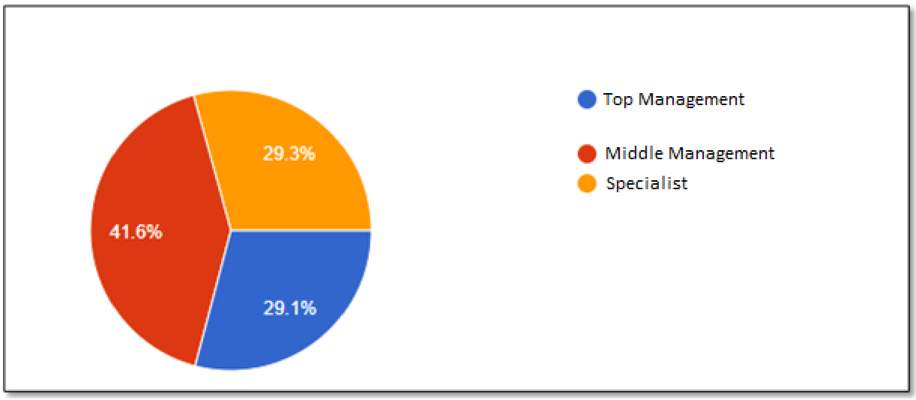


Figure 7.2: Respondent Position [source: own study]

The evaluation of position by the respondent was necessary to confirm the validity and reliability of responses and to understand the perspective of respondents.

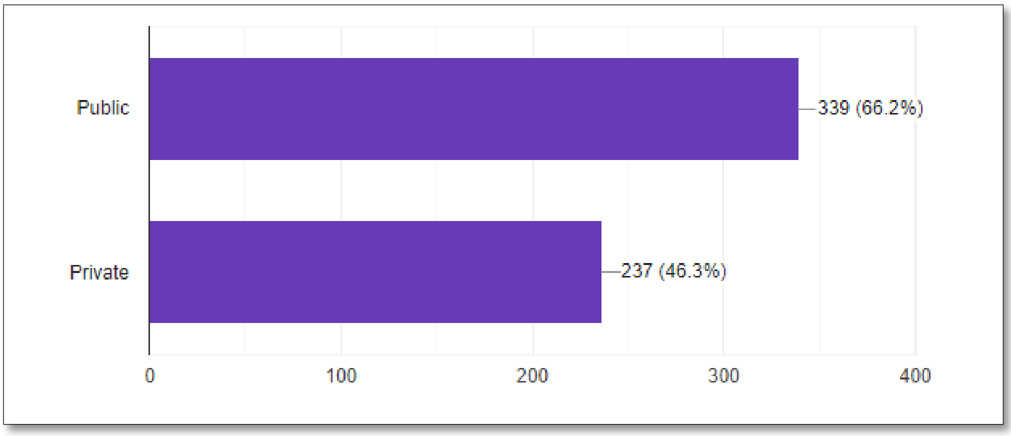


Figure 7.3: Respondent work category [source: own study]

The 66.2 % of the respondents were working in construction public (state) companies, 46.3 % in private construction companies. But in detalis It can be seen from table **6.13** that 33.8 % of the respondents were working in construction public (state) companies, 53.7 % in private construction companies, and 12.5 % mix of them. This is an indication that the questionnaire respondents are varied in the work Category.

7.2.3 Respondent Level of Education:

Figure 7.4 below provides the educational background of the respondents. The educational background ranges from bachelor’s degrees to higher studies. The majority, thus, 46.9 % had a bachelor’s degree, 37.7 % has a master's degree 15.4 % of them held certificates of Ph.D. studies. For that matter, it is accurate to conclude that the majority of those who responded to the survey are sufficiently experienced in the construction industry and are well-educated persons to provide data that is reliable and valid.

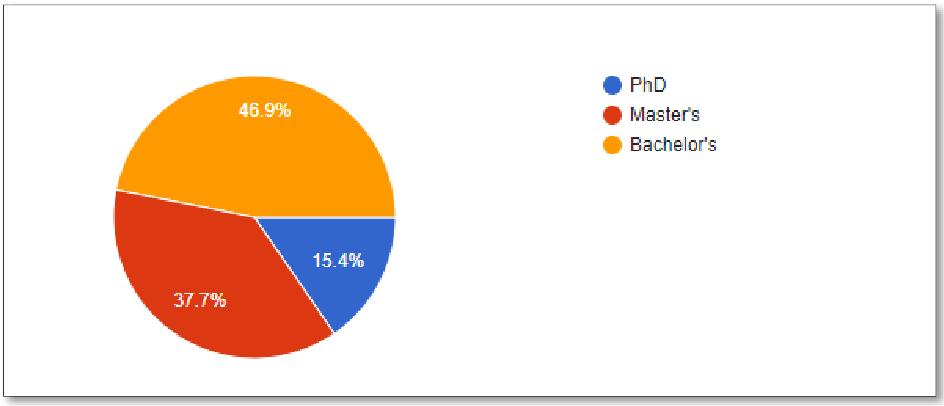


Figure 7.4: Respondent Level of Education [source: own study]

7.2.4 Respondent Years of Experience:

The greater the experience of the respondent in this sector the greater the understanding of the questions and necessary requirement for this sector. The highest frequency for the response was (1-5 years) as shown in Table (7.1). This group accounted for 25.8 % of the respondents and 16.03 % have greater than 21 years' experience.

This result is logical, since the respondents that have been targeted are that of higher classification, and broad experience.

Table 7.1: Percentage of Respondents Related to Experience Years [source: own study]

Experience in construction industry		Frequency	Percent	Cumulative Percent
	1-5 years	132	25.8 %	25.8 %
	6-10 years	97	18.94 %	44.74%
	11-15 years	119	23.2 %	67.94%
	16-20 years	82	16.03 %	83.97%
	21 – and above	82	16.03 %	100%
	Total	**512**	**100.0**	

7.2.5 Participant experiences:

This question gives the indicate whither the respondents of the questionnaire has the international experience or not in implementation construction projects, the international company can give more experience to deal with risks plans, many of international companies committed to follow risk guidelines.

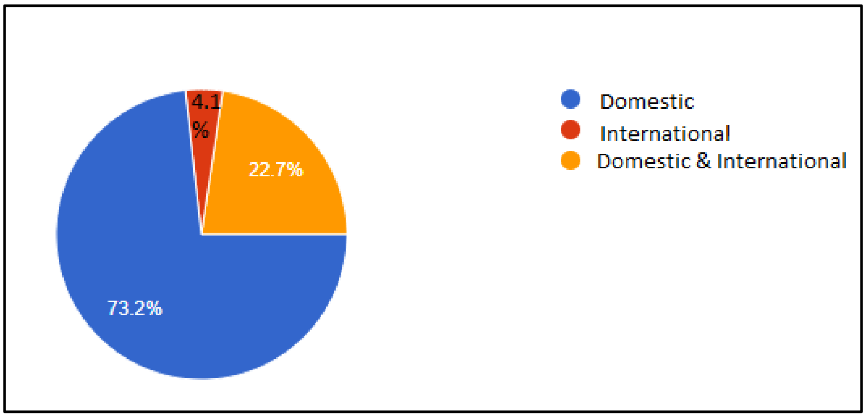


Figure 7.5: Project location class of for the participant (Domestic or Int.) [source: own study]

Figure 7.5 shows that only 4.1 % of participant worked in international construction and 22.7 % of participant worked in international construction and domestic while the majority (73.2%) are worked in local projects and moreover figure 7.7 shows that 52.7 % of participants didn't work with international companies were had a project in Iraq. That indicate there is no enough sharing of experience.

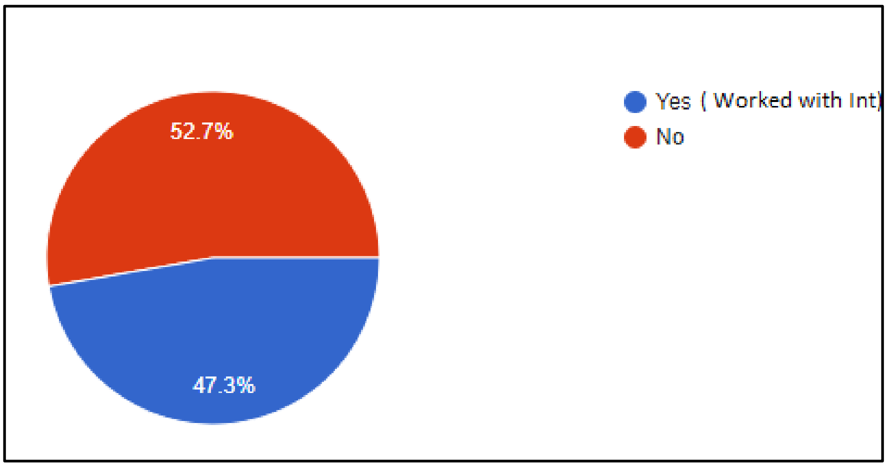


Figure 7.6: Illustrate Participant work history with Int. or local companies in Iraq [source: own study]

7.3 Evaluate the current level of risk factors in the Iraqi construction.

The following are the results gathered from section two. There were 4 questions for each risk factors category (12 categories) asked respondents to respond as below;

Q1: What is the impact of the factors on cost overruns of the construction projects?

Q2: What is the impact of the factors on the delay in completing the construction?

Q3: How often does it appear?

Q4: What is the impact of these factors on the occurrence of other risks? (Remaining groups)?

The excel sheet and questionnaire forms attached in appendix (**D**)

7.3.1 Respondents Perception of Construction mismanagement Risks

This category includes **5** risks factors as below;

Table 7.2: Illustrate Construction mismanagement risks factors[source: own study]

No	Risk Factor
1	Lack of planning and management
2	Lack of scope clarity or changes to the projects' scope and cost
3	Poor management
4	Inadequate Site planning and management
5	Delay in making decisions

The four questions were asked to evaluate the respondents' perception of this category of risks. The results are as shown below:

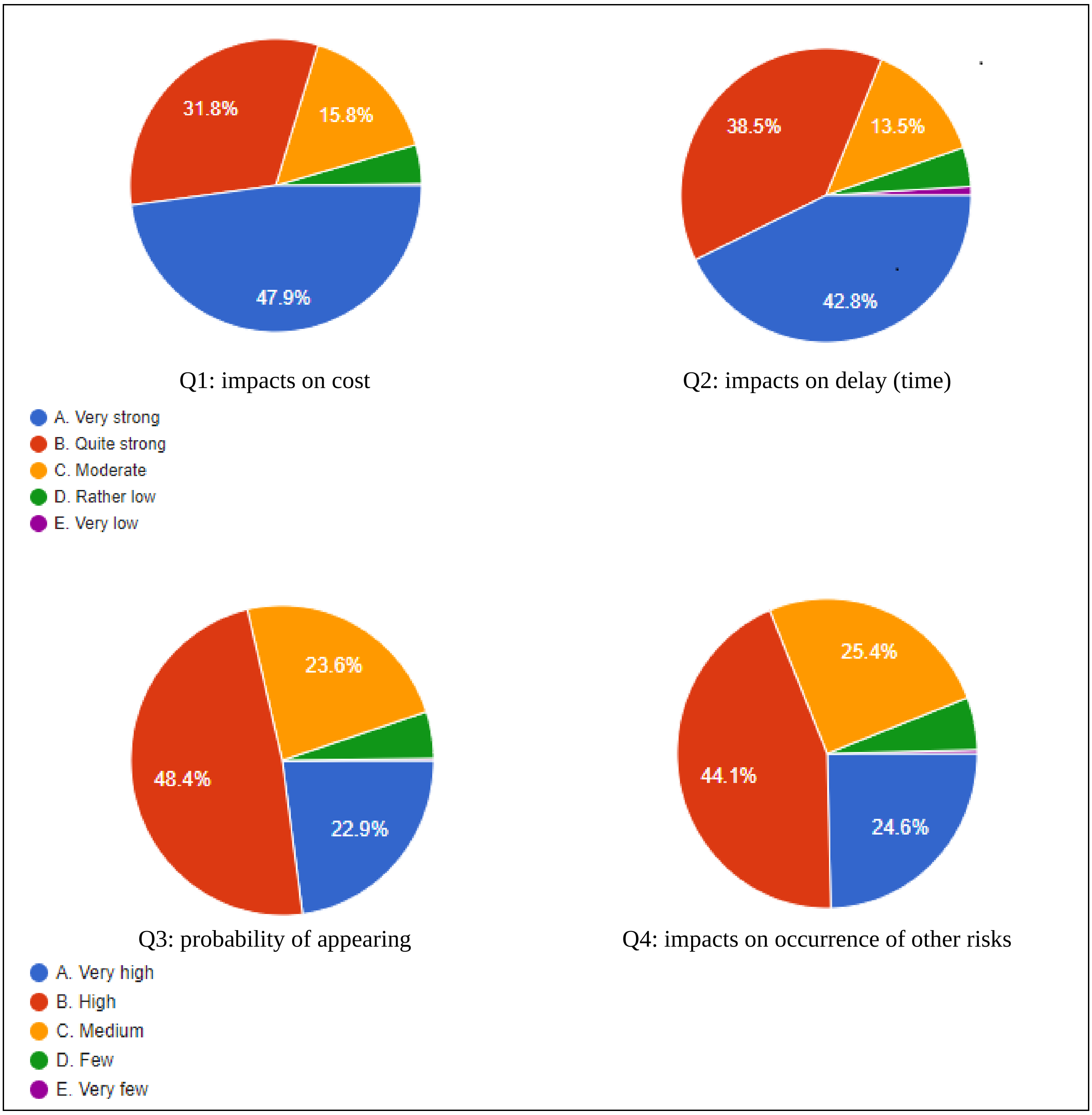


Figure 7.7: Illustrates Participant answers to the four questions for the risk category 1[source: own study]

The survey found that 47.9 % of respondents perceive risk factors due to mismanagement and the five factors listed are the cause of the over cost and 42.8% of respondents perceive the delay of the projects can be accrued due to the Lack of planning, Lack of scope clarity or changes to the projects' scope and, Delay in making decisions. While 48.4% of respondents perceive a high level of ensuring that this factor (5 factors of mismanagement category) can appear in construction and make an effect on the cost and time. The (44.1%) of respondents emphasize these factors' effect to accrue other risks.

7.3.2 Respondents Perception of Communication Risks

This category includes **2** risks factors as below;

Table 7.3: Illustrate Communication risks factors [source: own study]

No	Risk Factor
1	Poor communication with client/Imprecise expectation
2	Poor communication between the parties

The four questions were asked to evaluate the respondents' perception of this category of risks. The questions were asked to check the Communication orientation, and evaluate the existence of that and if it is active daily in work sites. The respondents responded that communication risks factors are in high rate up to 39.5 % can affect on the cost because of the poor of communication between parties.

Respondents largely agree that poor communication between project parties (stakeholders), lack of exchange of views, and the absence of a clear and approved communication plan in project management greatly affect, according to the respondents' vote 40.2%, 43.9 %, 42.6%, over cost and time and the emergence of new risks, these new risks can lead to the termination of the project.

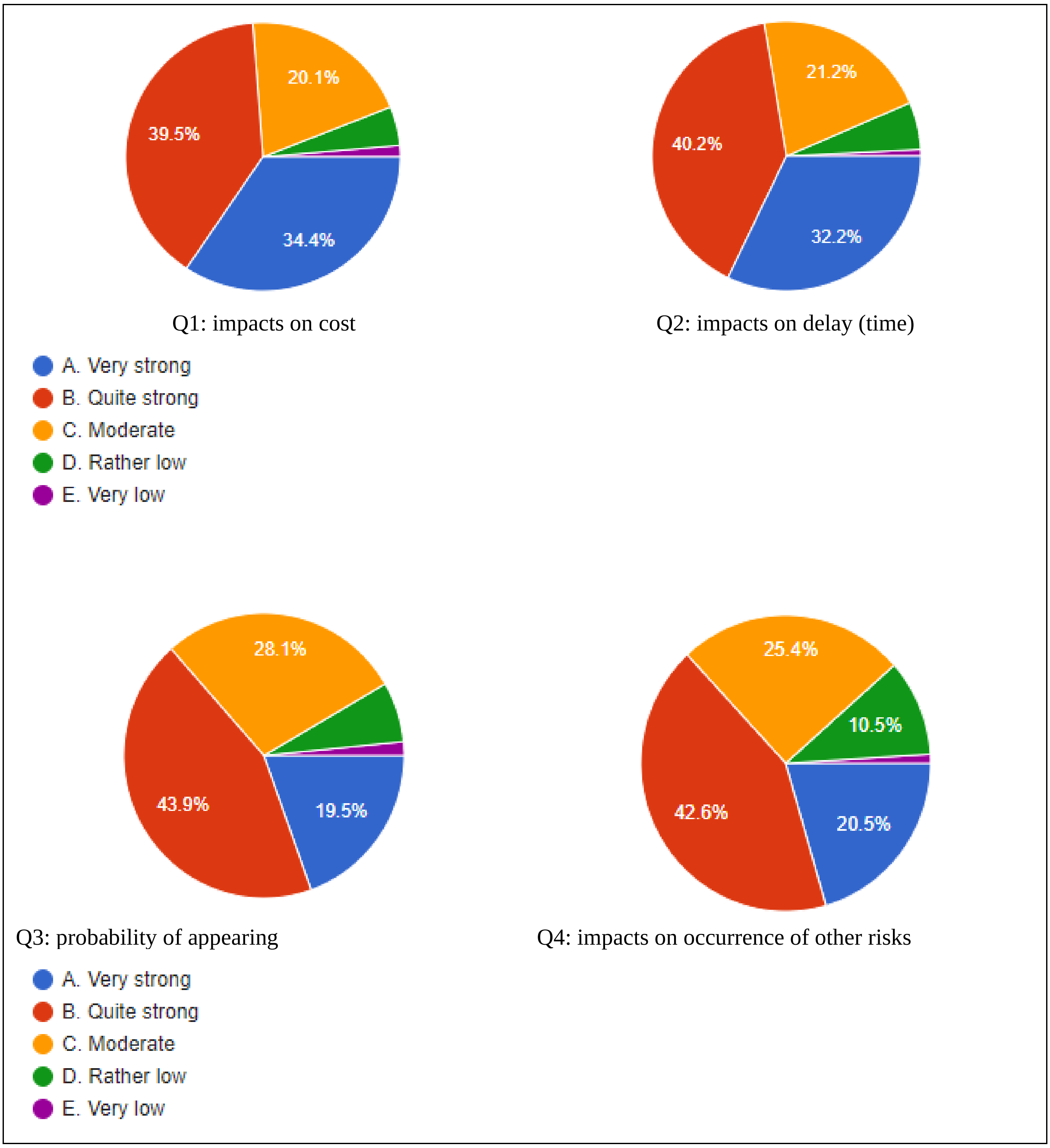


Figure 7.8: Illustrates Participant answers to the four questions for the risk category 2 [source: own study]

7.3.3 Respondents Perception of Financial Risks

This category includes **4** risks factors as below;

Table 7.4: Illustrate financial risks factors [source: own study]

No	Risk Factor
1	Financial problems of the client
2	Financial problems of the contractor
3	Delaying or refusing payments to contractors, subcontractors or workers
4	External economic factors (fluctuations of prices and interest rates, inflation, recession)

The four questions were asked to evaluate the respondents' perception of this category of risks. The financial risks related to the construction work directly affect the progress of the work, the respondents emphasized that the factors identified by the researcher influence a large percentage of the cost and time of the project, and this is evident in the delay in payments by the client to the main contractor and in the course of delaying the subcontractor's receipt of payments, and due to the fluctuations of the situation. The financial situation in Iraq, inflation, and the increase in the exchange rate also affected the cost and the emergence of other major risks, such as the delay in supplying materials for the project due to the high prices, which is evident in the percentages received from the questionnaire.

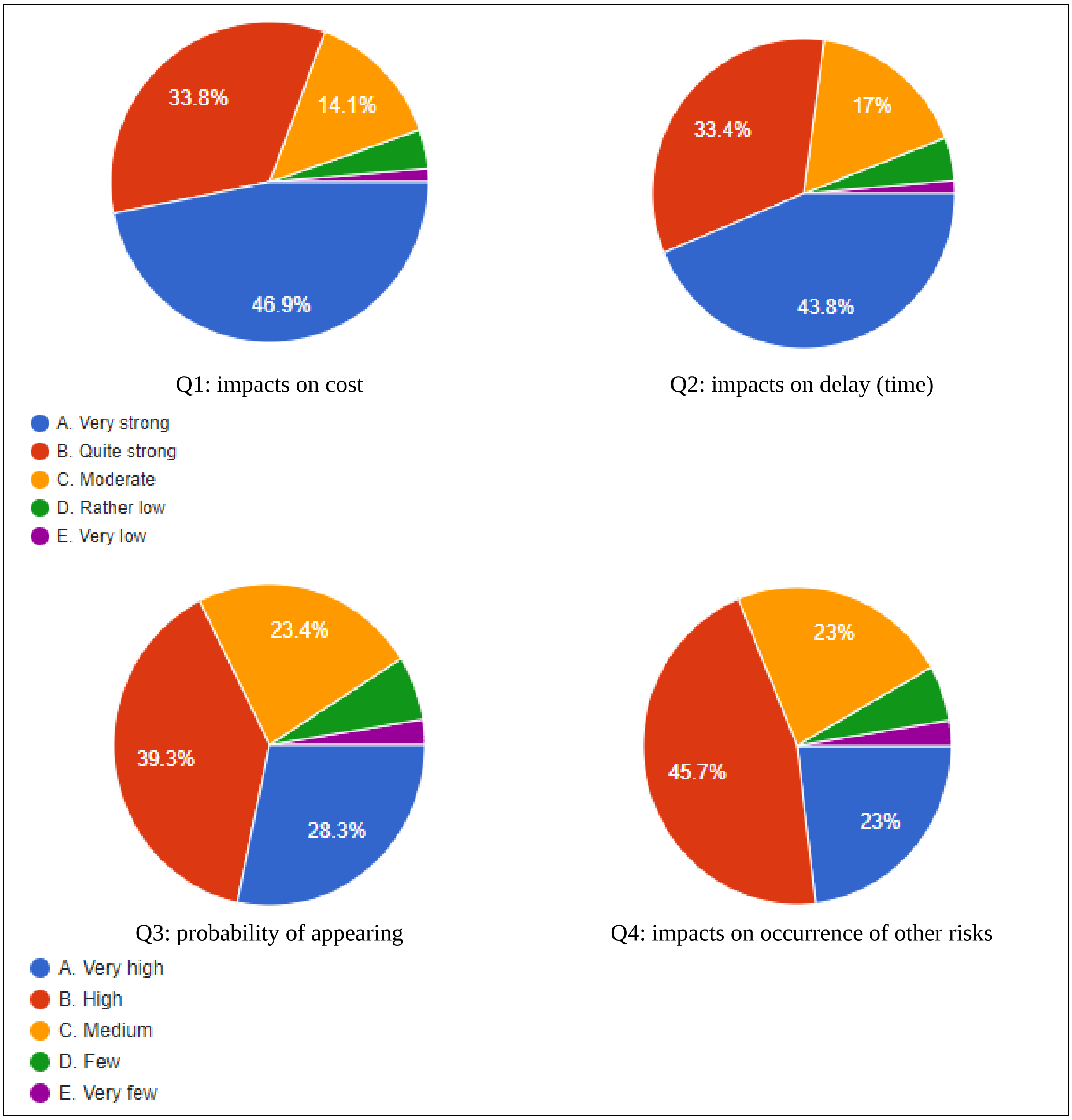


Figure 7.9: Illustrates Participant answers to the four questions for the risk category 3 [source: own study]

7.3.4 Respondents Perception of Legal Risks

This category includes **4** risks factors as below;

Table 7.5: Illustrate Legal risks factors [source: own study]

No	Risk Factor
1	Contractual Weakness
2	Terrorism and Sabotage
3	Inconsistencies and mistakes in contract documents
4	Changes in the applicable law

Contractual weakness is one of the important risks in controlling the cost of the project and generating new risks such as quality problems. In Iraq, contracting problems and claims between the project parties, as well as sabotage as a result of terrorism for many important projects such as electric and oil power transmission projects and infrastructure projects for some provinces. The 38.7 % +32.2 % of the respondents highly stressed these factors in their impact on the cost, 36.5 %+30.5 % on the project time, 36.5 %+ 30.5 % on their appearance, and 39.5 % +20.1% also stressed that these risks can be caused to occurrence other secondary risks that were not expected.

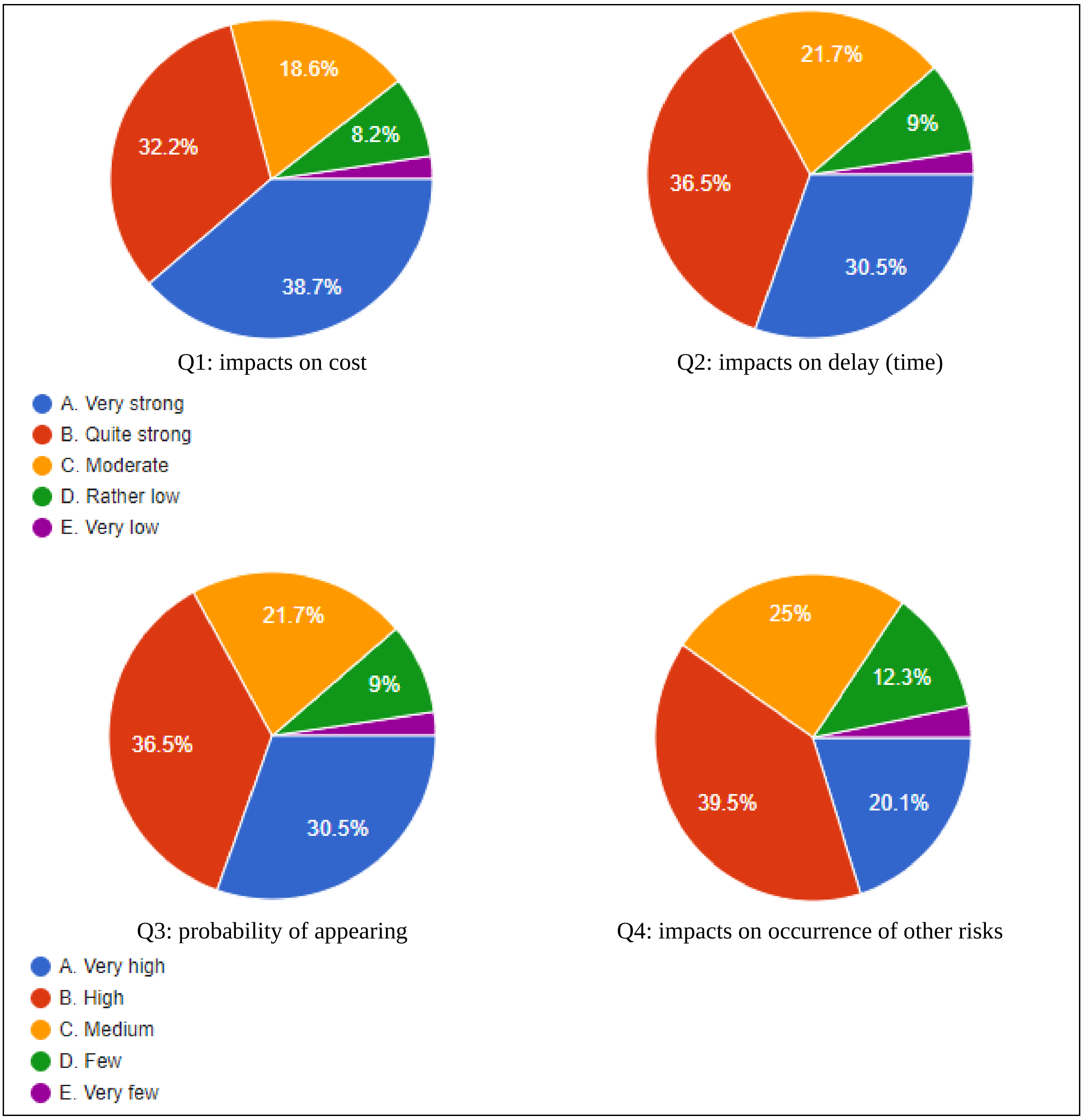


Figure 7.10: Illustrates Participant answers to the four questions for the risk category 4

[source: own study]

7.3.5 Respondents Perception of Market Risks

This category includes **3** risks factors as below;

Table 7.6: Illustrate Market risks factors [source: own study]

No	Risk Factor
1	Transportation and logistic
2	Lowest bidding procurement method
3	Delays in the delivery of materials

Respondents say that the transportation and logistics, the lowest method of bidding procurement, delays in the delivery of materials are the most commitment market risks on project. Figure 7.11 shows the high rate of respondents votes on the four questions.

Results showing that there is lack of commitment by the contracting companies and governmental companies to follow other methods in contractual and transportation. It is evident from the respondents' answers of that the understanding of new method of market is not sufficient.

Results show that, “Awarding the tender on the basis of lower prices and not efficiency”, is the most important problem affecting in construction companies in Iraq.

Interviews with a number of experts in the studied sample indicate that, the lowest evaluated bids mainly which values are under the project's estimated cost, may be occurring due to the lowest evaluated bidder poor experience or faults. And then, referring to that bidders may lead to delay in project execution, inability in paying obligations to suppliers, contractor financial losses or bankruptcy which adversely affecting the projects.

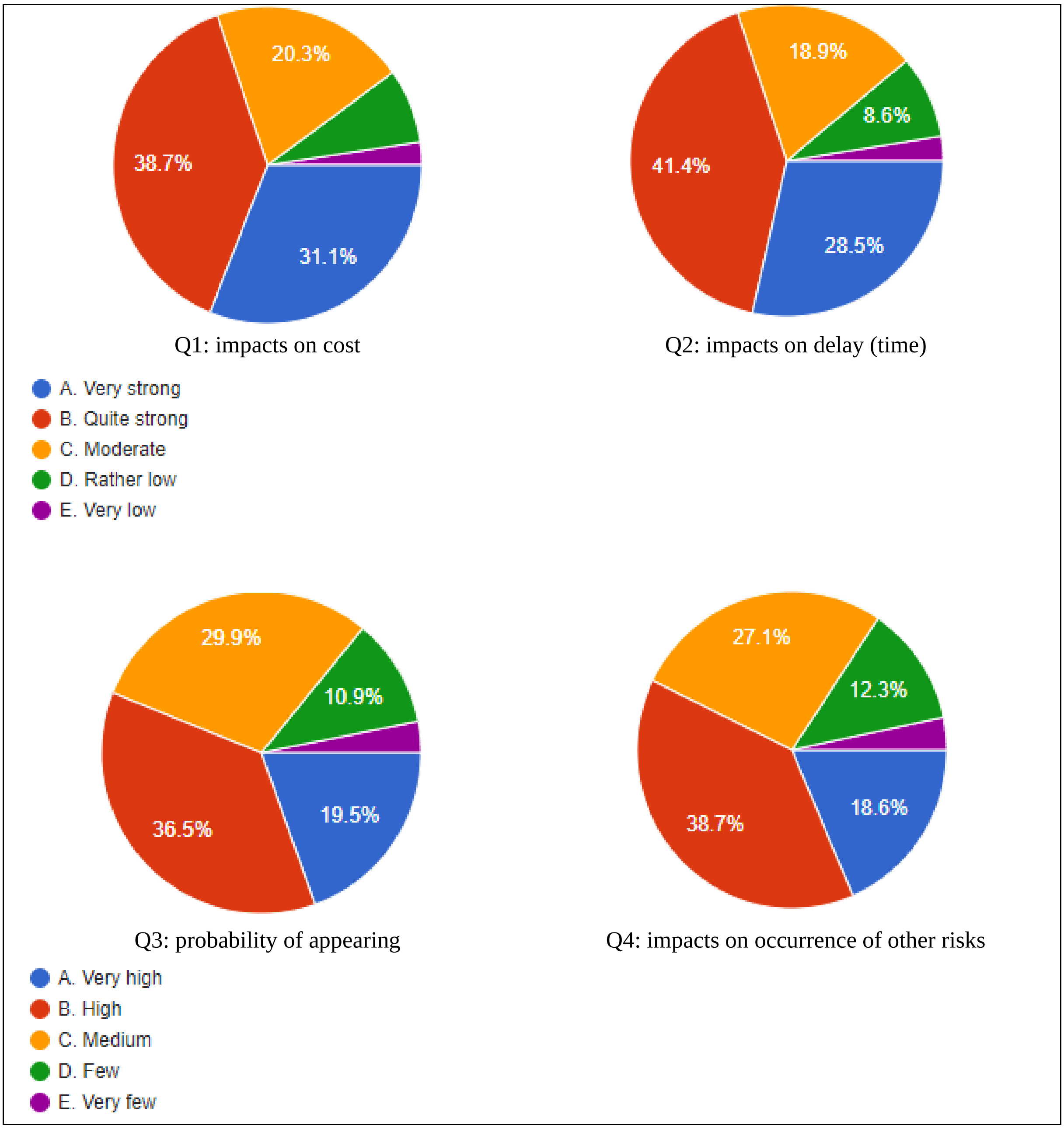


Figure 7.11: Illustrates Participant answers to the four questions for the risk category 5 [source: own study]

7.3.6 Respondents Perception of Policy and Politics Risks

This category includes **2** risks factors as below;

Table 7.7: Illustrate Policy and Politics risks factors [source: own study]

No	Risk Factor
1	Excessive bureaucracy
2	Delays due to complex political situation

The four questions were asked to evaluate the respondents' perception of this category of risks. The turbulent political situation and political problems in the country greatly affect the deterioration of the economic situation and the suspension of the five-year plans in one way or another. Therefore, the percentages of confirmation by the respondents were high, as shown below in Figure 7.12.

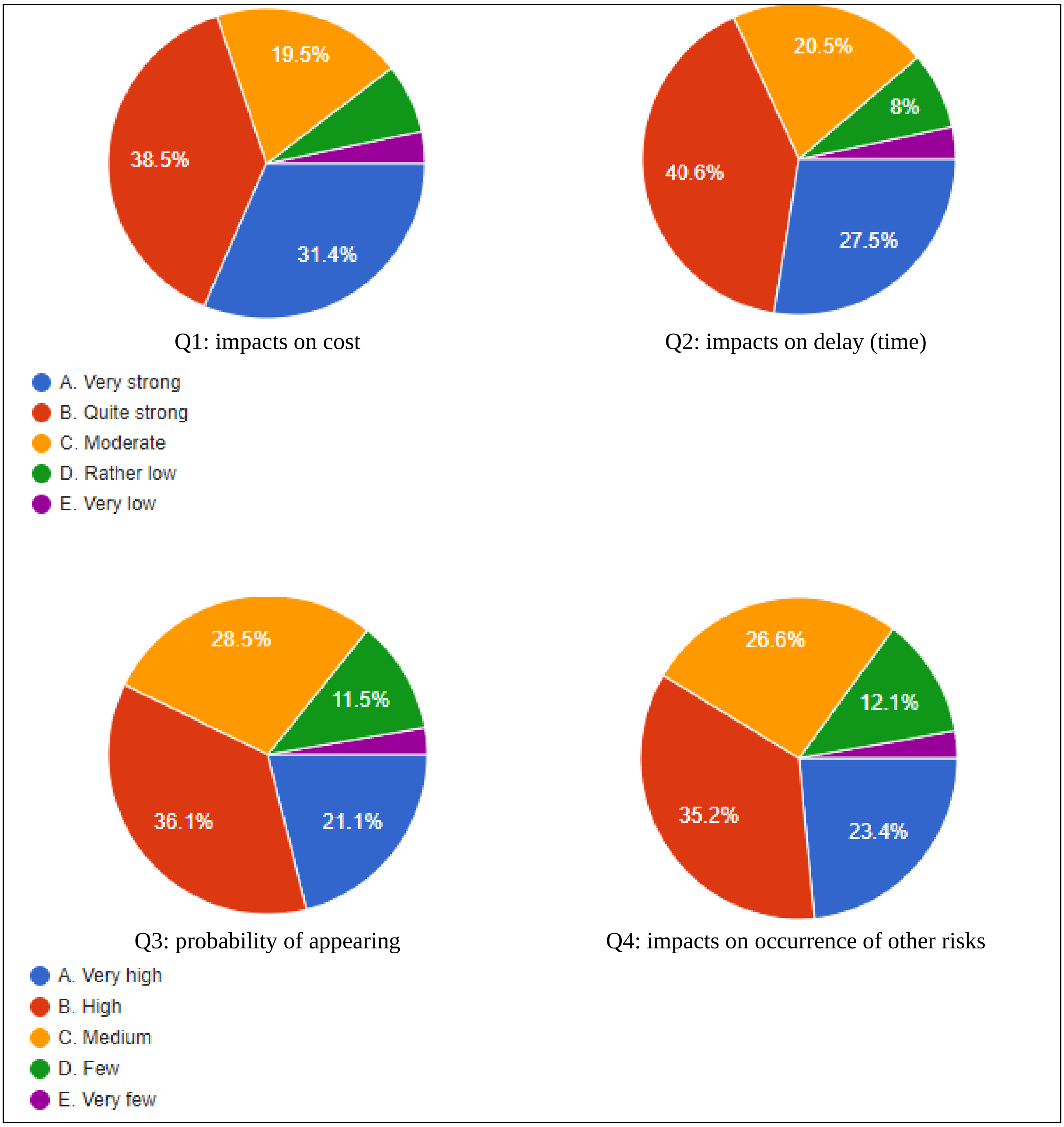


Figure 7.12: Illustrates Participant answers to the four questions for the risk category 6 [source: own study]

7.3.7 Respondents Perception of Technical Risks

This category includes **3** risks factors as below;

Table 7.8: Illustrate Technical risks factors [source: own study]

No	Risk Factor
1	Variation Works/Change order
2	Unforeseen ground conditions (lack of site investigation)
3	Time underestimation (inadequate time)

The four questions were asked to evaluate the respondents' perception of this category of risks. The confirmation rate of technical risk factors was highly rated and as shown below, and these factors must be taken into account when developing a risk plan.

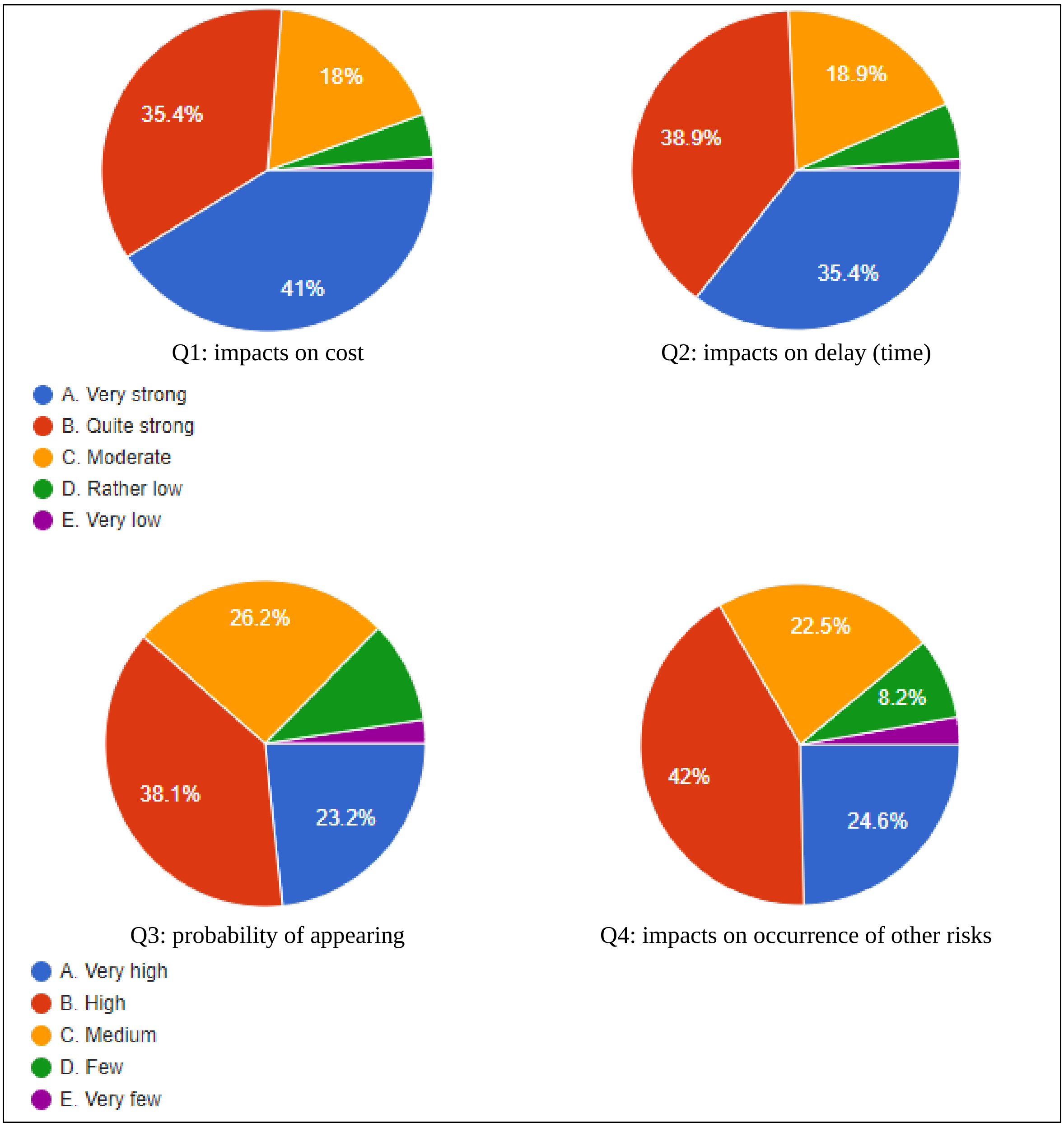


Figure 7.13: Illustrates Participant answers to the four questions for the risk category 7 [source: own study]

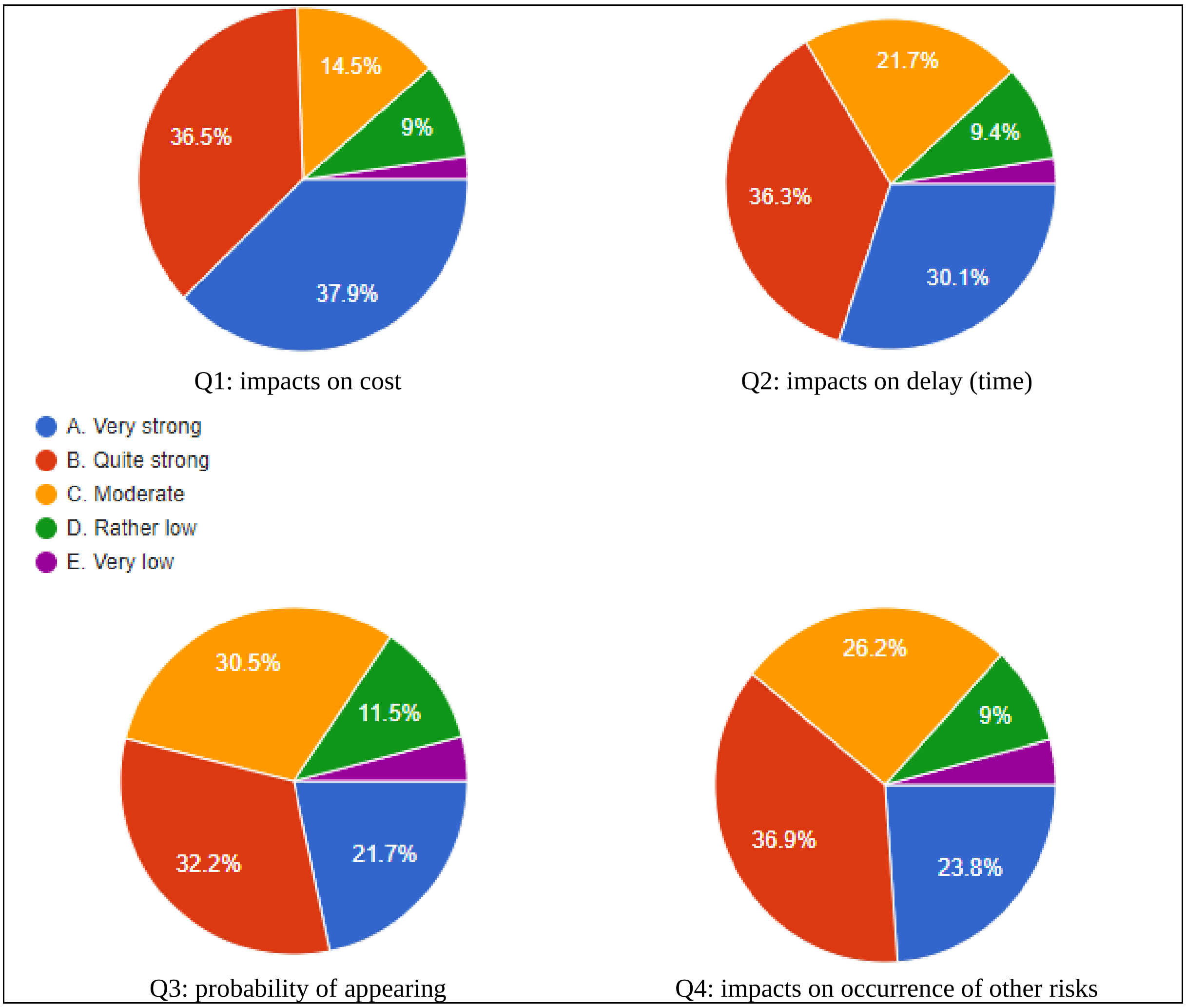
7.3.8 Respondents' Perception of the Risks of Design

This category includes **3** risks factors as below;

Table 7.9: Illustrate the Risks Design factors [source: own study]

No	Risk Factor
1	Errors in Design or changes
2	Design and drawing flaws
3	Inadequate architecture design

Majority of respondents representing 36.5% +37.9 % said that must check the design and drawings before commencement of project are prevent the actual cost risks to accrue while 36.3%+30.1 said that highly lead to delay, moreover these risks appearing at highly in projects as respondence percentage's answers. The four questions were asked to evaluate the respondents' perception of this category of risks. The results are as shown below:



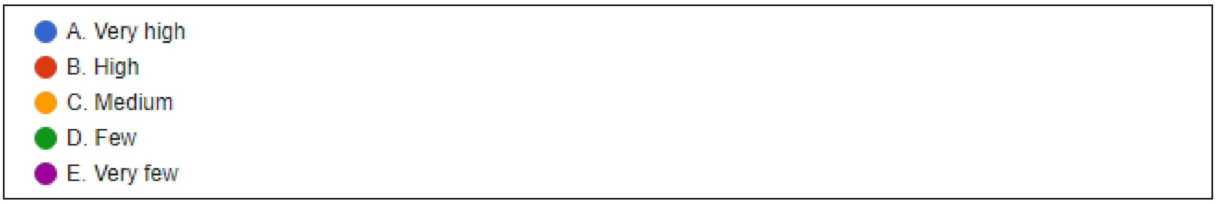


Figure 7.14: Illustrates Participant answers to the four questions for the risk category 8 [source: own study]

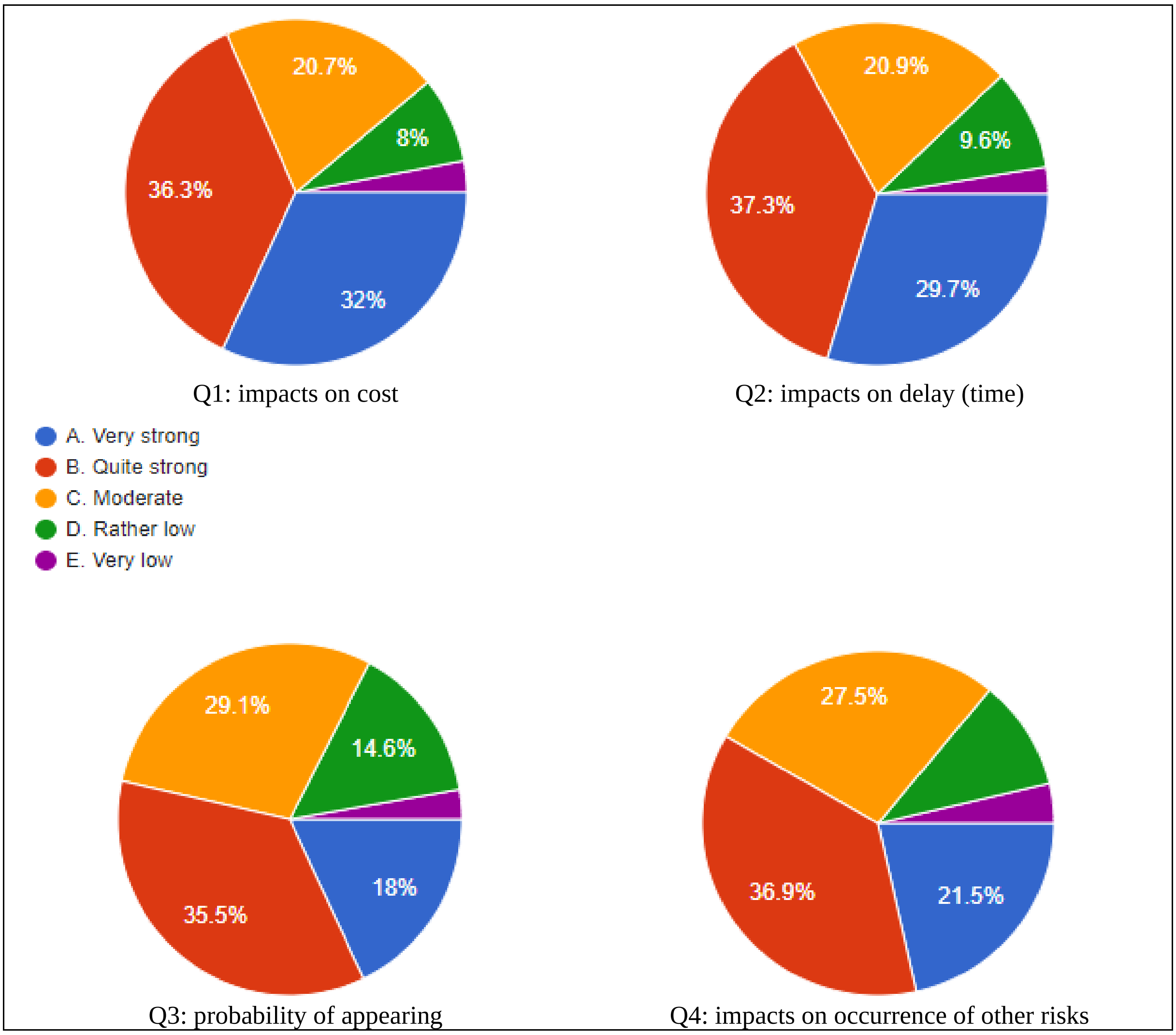
7.3.9 Respondents Perception of Human Resources Risks

This category includes **2** risks factors as below;

Table 7.10: Illustrate Human Resources Risks factors [source: own study]

No	Risk Factor
1	Insufficient number/lack of workers
2	Insufficient number/lack of qualified personnel

In this group, between the shortage of manpower and qualified manpower, their real and basic role is in creating real dangers during the implementation of the project. The results of the survey confirmed this fact.



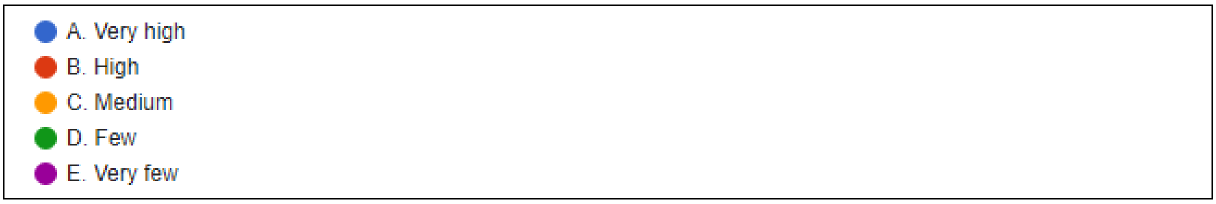


Figure 7.15: Illustrates Participant answers to the four questions for the risk category 9 [source: own study]

7.3.10 Respondents Perception of Risks in the mismanagement of quality

This category includes **2** risks factors as below;

Table 7.11: Illustrate Risks in the mismanagement of quality factors [source: own study]

No	Risk Factor
1	Reworks due to poor quality or flaws in execution
2	Poor quality or damage of building material

According to Figure (7.16) shown the results that there is lack of commitment by the contracting companies and governmental institutions to achieve quality. They should work hard and hard in this field in order to improve QMSs in their companies. It is evident from the respondents' answers of questions that the understanding of quality and implementing the QMSs is not sufficient.

Also, the current situation needs more attention and studies in this subject to clarify the quality concept to all parties of the construction industry.

Furthermore, this is an indication of the necessity of having QMSs in construction companies.

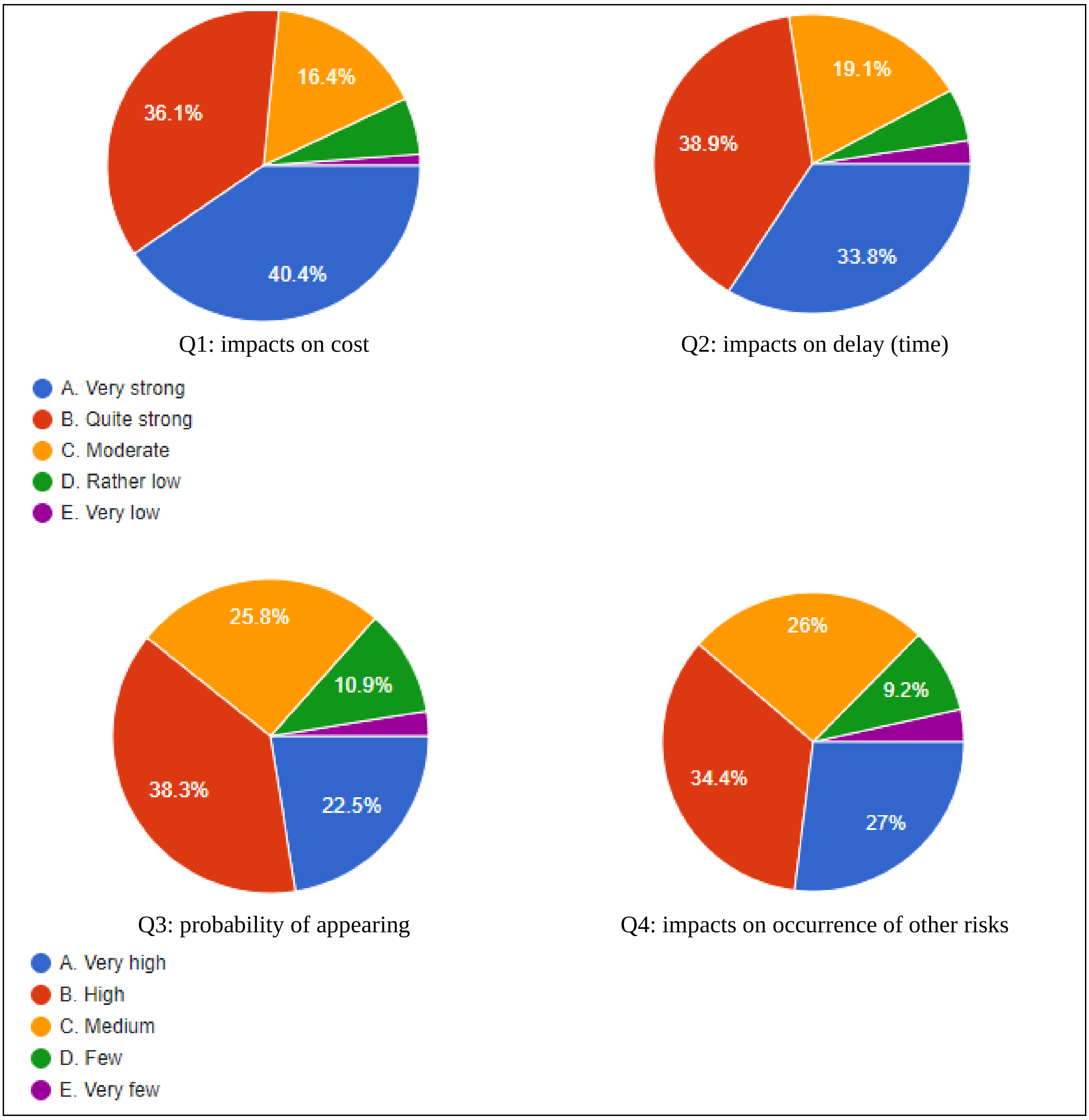


Figure 7.16: Illustrates Participant answers to the four questions for the risk category 10[source: own study]

7.3.11 Respondents Perception of Safety Risks

This category includes **3** risks factors as below;

Table 7.12: Illustrate Safety risks factors [source: own study]

No	Risk Factor
1	Lack of Safety in construction
2	Delays due to Incompetence, or lack of experience of workers
3	Random events (e.g., accidents)

The four questions were asked to evaluate the respondents' perception of this category of risks. Failure to follow the safety and security instructions on the site is the most important thing that the respondents voted on, and necessarily affects the time and cost factors in turn. The results are shown below:

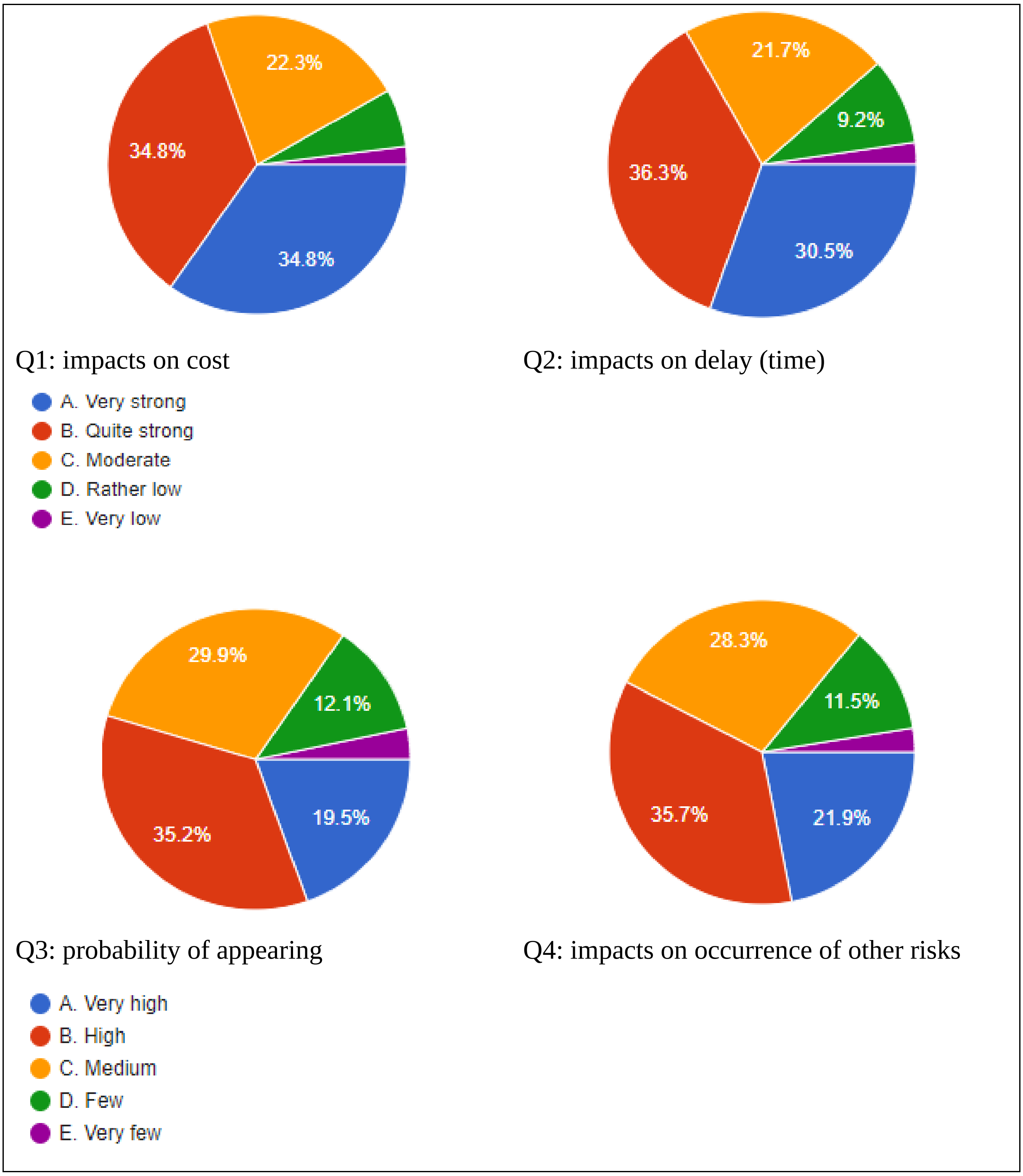


Figure 7.17: Illustrates Participant answers to the four questions for the risk category 11[source: own study]

7.3.12 Respondents Perception of Health Risks

This category includes **3** risks factors as below;

Table 7.13: Illustrate Health Risks factors [source: own study]

No	Risk Factor
1	Illness or death of workers
2	Low productivity of the workers (poor working conditions, low morale)
3	Bad weather or climate conditions

The rise in average temperatures in Iraq, which exceeded the 45 degrees Celsius barrier during the past five years, in turn affected the efficiency and productivity of the worker, and ultimately increased the implementation time.

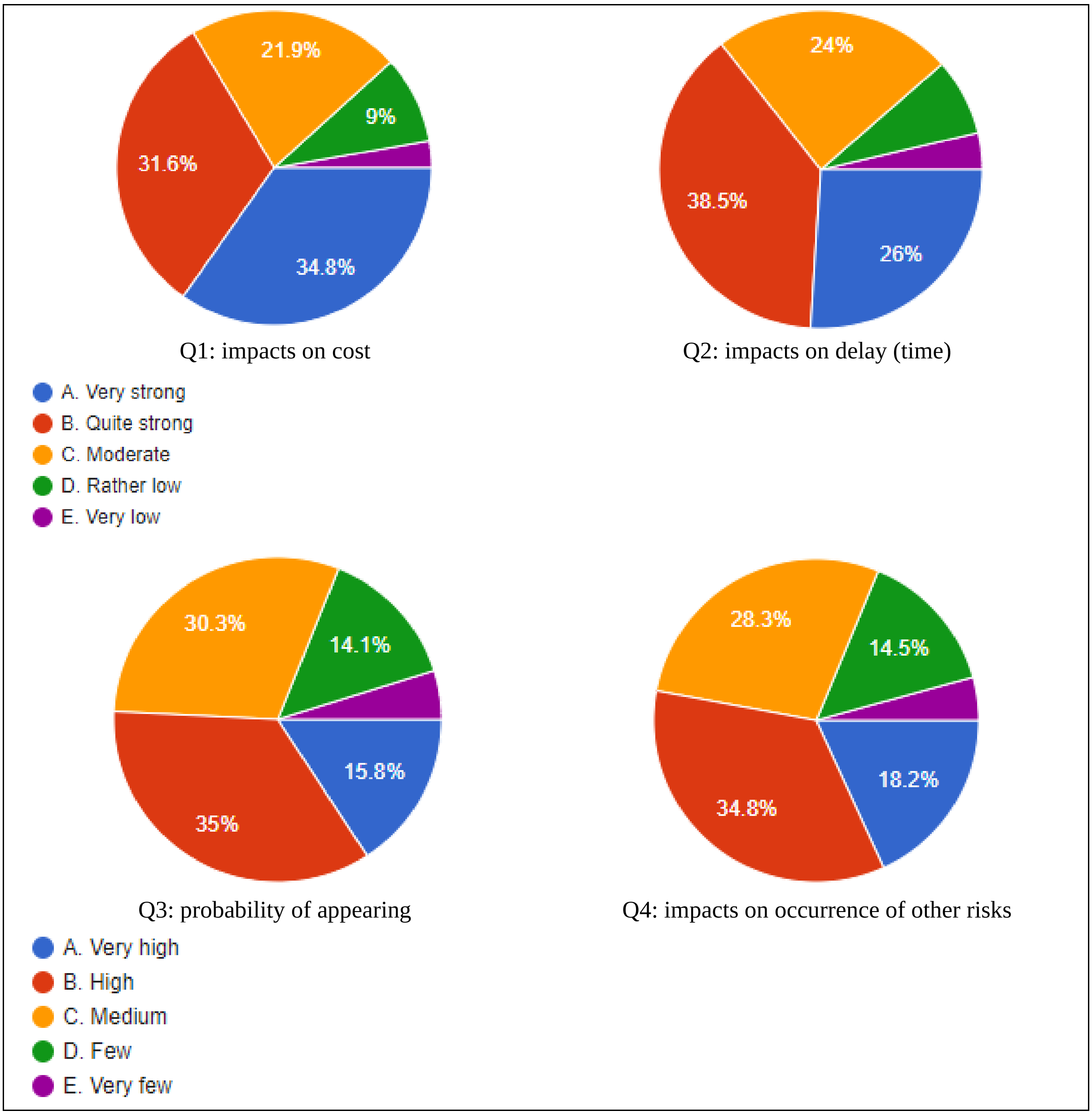


Figure 7.18: Illustrates Participant answers to the four questions for the risk category 12[source: own study]

Table 7.14: Shows the arithmetic means and standard deviations for each item [source: own study]

Questionnaire risk group	Questionnaire Questions	Mean	Std. Deviation
Construction mismanagement Risks	Q1	4.22	0.88
	Q2	4.14	0.89
	Q3	3.88	0.81
	Q4	3.87	0.85
Communication Risks	Q1	4	0.92
	Q2	3.97	0.91
	Q3	3.73	0.9
	Q4	3.71	0.94
Financial risks	Q1	4.2	0.92
	Q2	4.13	0.94
	Q3	3.84	0.99
	Q4	3.81	0.93
Legal risks	Q1	3.96	1.05
	Q2	3.83	1.03
	Q3	3.58	1.02
	Q4	3.61	1.03
Market risks	Q1	3.88	1
	Q2	3.84	1.01
	Q3	3.58	1.02
	Q4	3.56	1.03
Policy and Politics Risks	Q1	3.87	1.04
	Q2	3.81	1.03
	Q3	3.61	1.02
	Q4	3.64	1.05
Technical Risks	Q1	4.1	0.93
	Q2	4.1	0.93
	Q3	3.6	1.01
	Q4	3.77	1
Design Risks	Q1	3.99	1.03
	Q2	3.82	1.04
	Q3	3.55	1.07
	Q4	3.67	1.06
Human Resources Risks	Q1	3.86	1.04
	Q2	3.82	1.04
	Q3	3.51	1.03
	Q4	3.62	1.04
Risks in mismanagement quality	Q1	4.08	0.94
	Q2	3.95	0.99
	Q3	3.67	1.02
	Q4	3.72	1.06
Safety Risks	Q1	3.94	0.99
	Q2	3.83	1.03
	Q3	3.55	1.03
	Q4	3.62	1.02
Health Risks	Q1	3.86	1.07
	Q2	3.75	1.04
	Q3	3.42	1.06
	Q4	3.48	1.07

The researcher created the table based on the results of the SPSS program. From the table above the highest arithmetic mean appeared in paragraph (What is the impact of the above factors on cost overruns of the construction projects? Q1**)**, amounting to 4.22, and the lowest arithmetic mean appeared in paragraph (How often does it appear? Q3), amounting to 3.42.

By observing the values of the arithmetic means for all paragraphs and comparing them with the Likert scale (the hypothetical mean of the Likert scale is equal to 3), had the arithmetic means equal to 4.22, 4.14, 4, 4.2, 4.13, 4.1, 4.1, 4.08 Respectively, this means that the sample's answers tended towards (Very strong, Quite strong).

As for paragraph (What is the impact of the above factors on cost overruns of the construction projects?), where its arithmetic mean was equal to 4, we found that the sample's answers tended towards (Quite strong). Finally, we note that all the values of the arithmetic means were greater than the value of the hypothetical mean in the remaining items, meaning that the sample's answers tended towards (Very strong, Quite strong, and Moderate).

By observing the standard deviation values of the sample's answers, the smallest standard deviation value equals 0.81 in the paragraph (How often does it appear? Q3) in the Construction mismanagement Risks. In contrast, the largest value equals 1.07 in paragraph (How often does it appear? Q3) in the Design Risks. In general, the values of the standard deviations in all paragraphs show that the sample's answers to the questions in the paragraphs were reasonably homogeneous and Clear.

7.4 Ranking importance of risk categories in construction sector in Iraq

Having identified factors critical to risk management in the Iraqi construction industry, it is necessary to rank these categories according to their importance from the construction companies' respondents' viewpoint.

In order to analyse each factor, each risk category was ranked for each particular factor according to the value of its average, starting from the largest average to the most minor average by giving the value 1 for the statement that has the lowest average value and so on. According to the five-point Likert scale, when the statement means increases, its importance also increases. The statement with the ranking number of values 1 means that it has the lowest importance among the other statements in the main one and the value 5 means the highest level of importance. In order to understand the findings of the study, the mean key in Table 7.15 shown below will be useful.

Table 7.15: Mean key for the findings of the study [source: own study]

Mean	Level of Importance
1 – 2.33	Low
2.34 – 3.67	Moderate
3.68 – 5	High

The Cronbach's alpha

The Cronbach's alpha equation below is best understood as a function of the number of questions, the between pairs of items average covariance, and the overall variance of the total measured score, moreover Cronbach's alpha is a convenient test used to estimate reliability through internal consistency, when a significant reliability score (i.e., consistent) means that results produce similar results when the same person repeats the questionnaire, under the same conditions. However, Cronbach's alpha (equation below) has some limitations such that results with a small number of associated items tend to have lower reliability, and sample size also affects reliability results [120].

$$\alpha = \left(\frac{k}{k-1}\right)\left(1 - \frac{\sum_{i=1}^{k} \sigma_y^2}{\sigma_x^2}\right) \quad \ldots\ldots\ldots.\ Alpha\ Cronbach\ equation$$

Where:

α: *Alpha Cronbach coefficient*

k: *The number of items in the measure*

σ_y^2: *Variance associated with each*

σ_x^2: *variance associated of the total scores*

Since the study is concerned with the impact of risk factors on two main factors on which the success of any construction project depends, which are cost and time, all categories will be analysed and ranging, as shown below:

- **Ranging according to the effects of factors on cost**

The 36 risk factors were analyzed and their arithmetic means, and standard deviations. The stability level of Cronbach Alpha was found for each risk category regarding the impact of these risks on the cost factor.

Table 7.16: Illustrate mean and the Cronbach alpha in cost affect [source: own study]

Category	The factor impact	N	Mean	Std. Deviation	Alpha	Level
5	Cost	512	3.87	1.041	0.766	High
8	Cost	512	3.87	1.047	0.776	High
11	Cost	512	3.87	1.075	0.768	High
4	Cost	512	3.88	1.009	0.771	High
10	Cost	512	3.94	0.997	0.769	High
3	Cost	512	3.97	1.055	0.780	High
7	Cost	512	3.99	1.038	0.766	High
1	Cost	512	4.01	0.926	0.786	High
12	Cost	512	4.01	0.926	0.772	High
9	Cost	512	4.09	0.950	0.764	High
6	Cost	512	4.10	0.936	0.774	High
2	Cost	512	4.21	0.920	0.778	High
Average			**3.984**		**0.772**	**High**

The researcher found that the level of stability is high, meaning that the same results can be obtained if they are in the same terms and conditions of this questionnaire. Through the five-point Likert scale, the researcher found that all respondents are within the high level**.**

- **Ranging according to the effects of factors on time**

The impact of risk factors is high on the time factor during the analysis conducted by the researcher, and the level of stability ranges between 0.815 in category mismanagement risk factors and lowest 0.794 in Human Resources Risk factors.

Table 7.17: Illustrate mean and the Cronbach alpha in time affect [source: own study]

Category	The factor impact	N	Mean	Std. Deviation	Alpha	Level
12	Time	512	3.75	1.043	0.805	High
6	Time	512	3.81	1.032	0.805	High
9	Time	512	3.82	1.043	0.794	High
8	Time	512	3.82	1.044	0.801	High
11	Time	512	3.83	1.036	0.805	High
4	Time	512	3.84	1.033	0.803	High
5	Time	512	3.85	1.013	0.803	High
10	Time	512	3.96	0.992	0.797	High
2	Time	512	3.97	0.912	0.804	High
7	Time	512	4.02	0.936	0.799	High
3	Time	512	4.14	0.945	0.810	High
1	Time	512	4.18	0.890	0.815	High
Average			**3.915**		**0.803**	**High**

7.5 Spearman's Rank-Order Correlation

The Spearman rank-order correlation coefficient is a nonparametric measure of the strength and direction of association that exists between two variables measured on at least an ordinal scale. It is denoted by the symbol r_R (or the Greek letter ρ, pronounced rho). The test is used for either ordinal variable as the current case between the 12 variables measuring the correlation of variables with each other.

$$\rho = 1 - \frac{6\sum_i d_i^2}{n(n^2-1)} \qquad \dots\dots\dots. \qquad Spearman\ equation$$

n= number of data points of the two variables

di= difference in ranks of the "ith" element

The Spearman Coefficient, ρ, can take a value between +1 to -1 where,

- ρ value of +1 means a perfect association of rank
- ρ value of 0 means no association of ranks
- ρ value of -1 means a perfect negative association between ranks.

Closer the ρ value to 0, weaker is the association between the two ranks [121].

Some distinctive results obtained from the spearman correlation coefficient will be addressed depending on the above equation.

Table7.18 Shows Spearman correlation values between risks [source: own study]

Risk axes in Iraqi construction projects	first axis	second axis	third axis	fourth axis	fifth axis	sixth axis	seven axis	eighth axis	ninth axis	tenth axis	eeleventh axis	twelfth axis
first axis	1	0.309	0.326	0.298	0.297	0.244	0.334	0.328	0.294	0.343	0.247	0.232
second axis	0.309	1	0.333	0.393	0.404	0.399	0.391	0.303	0.398	0.380	0.354	0.371
third axis	0.326	0.33	1	0.409	0.349	0.371	0.349	0.344	0.296	0.348	0.263	0.227
fourth axis	0.298	0.393	0.409	1	0.513	0.436	0.409	0.409	0.372	0.372	0.338	0.294
fifth axis	0.297	0.404	0.349	0.513	1	0.504	0.469	0.465	0.480	0.436	0.422	0.391
sixth axis	0.244	0.399	0.371	0.436	0.504	1	0.419	0.391	0.394	0.373	0.383	0.331
seventh axis	0.334	0.391	0.349	0.409	0.469	0.419	1	0.570	0.466	0.452	0.460	0.423
eighth axis	0.328	0.303	0.344	0.409	0.465	0.391	0.570	1	0.515	0.449	0.420	0.301
ninth axis	0.294	0.398	0.296	0.372	0.480	0.394	0.466	0.515	1	0.518	0.445	0.436
tenth axis	0.343	0.380	0.348	0.372	0.436	0.373	0.452	0.449	0.518	1	0.467	0.425
eleventh axis	0.247	0.354	0.263	0.338	0.422	0.383	0.460	0.420	0.445	0.467	1	0.596
twelfth axis	0.232	0.371	0.227	0.294	0.391	0.331	0.423	0.301	0.436	0.425	0.596	1

Where:

first axis/ construction risks, second axis/ communication risks, third axis/ financial risks, fourth axis/legal risks, fifth axis/market risks, sixth axis/ policy and politics risks, seventh axis/ technical risks, eighth axis/ design risks, ninth axis/ human risks, tenth axis/ risks in quality, eleventh axis/ safety risks, twelfth axis/ health risks.

From the table (7.18) of the correlations between the risk coefficients that a large portion of the Spearman correlation values was weak, which means there is no correlation between these variables, and this is necessary to conduct hypothesis testing (the explanatory variables must be linearly independent, there is no relationship between them). However, observing the Spearman correlation values, some of the correlation values for these variables are moderate, meaning there is a relationship between these variables (risk axes). These axes are (legal risks, market risks), (technical risks, design risks), (design risks, human risks), (human risks, risks in quality), and (risks in quality, safety risks). To solve this problem, the method of adding the ridge parameter and then testing the study hypotheses is used.

7.6 Hypotheses testing

This section outlines the statistical difference between participants in this study. Independent Samples Test (T-Test for Equality of Means) are used to explain these differences; the test is used because correlations between qualitative and quantitative factors will be tested, as well as the need to highlight whether the means of several variables are equal or not. A T-test was conducted to find if there is a significant difference between the ranking of parties on a questionnaire regarding the importance of risk factors. The t- test calculated formula shown as below [122].

$$t = \frac{\bar{X} - \mu}{\frac{s}{\sqrt{n}}} \qquad t - test\ equation$$

Where:

$\bar{x}$ = It is the observed mean, i.e., the sample’s mean value.

μ = It is the theoretical or population mean, i.e., the population’s mean value.

s = It is the standard deviation of the sample.

n = It is the sample size, i.e., the number of observations in the sample (512).

A T-test was carried out on the average weighted factors resulting from ranking factors affecting risk in section 4 of the questionnaire. This section outlines the statistical difference between participants in this study. Independent Samples Test (T-Test for Equality of Means) is used to explain these differences; the test is used because correlations between qualitative and quantitative factors will be tested, as well as the need to highlight whether the means of several variables are equal or not. The T-test method compares the means of the qualitative independent variable which has two levels. In this case, the dependent variables are quantitative. The summary of the test is shown below:

- **T-Test According to risks Factors categories the (12) and the five Participants Party (Engineers, Investors, Designers, Contractors, Subcontractors).**

Study question No. 1: What is the impact of the factors on cost overruns of construction projects?

H_1: There is a significant difference in perception between the participants with regard to the risk factors affecting projects costs.

H_0: There is no significant difference in perception between the participants with regard to the risk factors affecting the projects costs.

Table 7.19: Illustrate the T-test for the first hypotheses [source: own study]

Risk Categories	df	Arithmetic mean	Standard deviation	Hypothetical mean	Calculated T-value	significance
Construction mismanagement Risks	511	4.23	0.88	3	31.57	Positive significant
Communication Risks	511	1.01	0.93	3	24.63	Positive significant
Financial Risks	511	4.21	0.92	3	29.73	Positive significant
Legal Risks	511	3.97	1.05	3	20.74	Positive significant
Market Risks	511	3.88	1.01	3	19.84	Positive significant
Policy and Politics Risks	511	3.87	1.04	3	19.02	Positive significant
Technical Risks	511	4.10	0.94	3	26.68	Positive significant
Design Risks	511	3.99	1.04	3	21.58	Positive significant
Human Resources Risks	511	3.87	1.05	3	18.71	Positive significant
Risks in mismanagement quality	511	4.09	0.95	3	25.92	Positive significant
Safety Risks	511	3.94	0.99	3	21.36	Positive significant
Health Risks	511	3.87	1.08	3	18.25	Positive significant

Where:

df: degree of freedom

The researcher created the table based on the results of the SPSS program. The tabular T-value is at a significance level of (0.05) and a degree of freedom (511) = 1.97

From Table (7.19) the calculated T-value was greater than its tabular value at the level of significance (0.05) and the degree of freedom (511), which is (T -table = 1.97) [123]. This means that there is statistical significance in risk perception, and since the value of the arithmetic mean is greater than the value of the hypothetical mean (3) for all risk groups, this means that the hypothesis H_1 is accepted.

- **T-Test According to risks Factors categories the (12) and the five Participants Party (Engineers, Investors, Designers, Contractors, Subcontractors).**

Study question No. 2: What is the impact of the factors on delay of construction projects?

H_1: There is a significant difference in perception between the participants with regard to the risk factors affecting projects schedule.

H_0: There is no significant difference in perception between the participants with regard to the risk factors affecting the projects schedule.

Table 7.20: Illustrate the T-test for the second hypotheses [source: own study]

Risk Categories	df	Arithmetic mean	Standard deviation	Hypothetical mean	Calculated T-value	significance
Construction mismanagement Risks	511	4.18	0.89	3	29.94	Positive significant
Communication Risks	511	3.97	0.91	3	24.17	Positive significant
Financial Risks	511	4.14	0.95	3	27.22	Positive significant
Legal Risks	511	3.84	1.03	3	18.35	Positive significant
Market Risks	511	3.85	1.01	3	18.94	Positive significant
Policy and Politics Risks	511	3.81	1.03	3	17.76	Positive significant
Technical Risks	511	4.02	0.94	3	24.55	Positive significant
Design Risks	511	3.82	1.04	3	17.77	Positive significant
Human Resources Risks	511	3.82	1.03	3	17.80	Positive significant
Risks in mismanagement quality	511	3.96	0.99	3	21.83	Positive significant
Safety Risks	511	3.83	1.03	3	18.21	Positive significant
Health Risks	511	3.75	1.04	3	16.32	Positive significant

From Table (7.20) the calculated T-value was greater than its tabular value at the level of significance (0.05) and the degree of freedom (511), which is (T -table = 1.97).

This means that there is statistical significance in risk perception, and since the value of the arithmetic mean is greater than the value of the hypothetical mean (3) for all risk groups. This means that the hypothesis H_1 is accepted.

7.7 Summary of the chapter

In this chapter, the outputs of the questionnaire, which was distributed to more than 600 specialists in the field of construction, were reviewed. The data received from 512 respondents and analysed statistically, and the most important conclusions were:

- Most of the respondents confirmed that the risks are high importance and could cause problems in the project. This was evident in the risk assessment ratios, most of which were high for the twelve groups.
- The third question (Question 3; How often does it appear?) contained in the questionnaire was answered by the respondents. It is sufficient to suffice with the percentage stated in the questionnaire, which was high for most of the group's emphasis to appearing that type of risks by high percentages as shown in figures (7.7 - 7.18).
- The respondents answered Question 4; What is the impact of these factors on the occurrence of other risks? (Remaining groups), the possibility of effect and other risks may occur, and this was evident in very high and high voting in questionnaire outputs as shown in figures (7.7 - 7.18).
- Through the data, an arrangement was made for the most important risks that affect the cost and time of the project, according to the Cronbach Alpha values and the five-point Likert classification.
- The correlation between the risk group was studied by Spearman coefficient and the values range (0.244 -0.596) are classified between weak and moderate correlation, the research conducted that the weak correlation (0.244) (Construction management risks and Policy and Politics risks) and moderate correlation (0.596) (Safety Risks and Health Risks).
- The researcher also found, by examining the T-test that the two hypotheses of the research H_1 are accepted.

The next chapter will be a new application to complete what was done in the previous chapters, using the principle of lean-risk management in completing the analysis of the data received from the questionnaire and obtaining important outputs that benefit the study in reaching the research goal in a new way.

8 Lean Thinking on Addressing the Risks Factors

This chapter is a new way to address the uncertainty found in Iraqi projects as an effective tool in Lean Thinking in RM.

8.1 Lean Thinking

Lean Thinking provides a way to specify value, line up value-creating actions in the best sequence, conduct these activities without interruption whenever someone requests them, and perform them more and more effectively. Lean Thinking provides a way to do more and more with less and less— less human effort, less equipment, less time, and less space—while coming closer and closer to providing customers with exactly what they want.

Lean Thinking also provides a way to make work more satisfying by providing immediate feedback on efforts to convert waste into value [30].

The five principles of Lean Thinking are:

- Specify value from the standpoint of the end customer by product family.
- Identify all the steps in the value stream for each product family, eliminating whenever possible those steps that do not create value.
- Make the value-creating steps occur in tight sequence so the product will flow smoothly toward the customer.
- As flow is introduced, let customers pull value from the next upstream activity.
- As value is specified, value streams are identified, wasted steps are removed, and flow and pull are introduced, repeat this process again and continue it until a state of perfection is reached in which perfect value is created with no waste [30].

Lean manufacturing implementation in organization helps in proper structuring of processes and maximum waste reduction which leads to improved performance [30].

8.2 Lean Six Sigma

Six Sigma, inhibits the process variation on priority by imparting the entire process towards mean [30].

The six-sigma management philosophy can be summarized as:

- Measurement — Specify quality and value in the eyes of customers, and measure customer requirement and process performance;
- Transparency — Management decision is based on data and fact, as well as understanding the gap through benchmarking;
- Optimization — Adopting a proactive approach to optimizing processes;
- Systemizing — An inherent focus to eliminate waste and variation throughout the entire value chain, and then standardizing the process;
- Consistency — Involve and empower all employees to cooperate without boundaries, and the existence of a mechanism to ensure the implementation and operation of optimized processes;
- Quality Culture — Continuous improvement in pursuit of perfection [30].

When Six Sigma tools are implemented in an organization, it results in improved organizational performance rather than other quality approaches [31].

Lean Six Sigma is a philosophy comprising a number of organizational factors that are critical to the successful deployment in which the senior Six Sigma facilitators adopt the Six Sigma methodology referred to as define-measure-analyse-improve-control (DMAIC) phases, and within each phase, various statistical and lean tools are selected as appropriate [124].

The hybrid development of Lean and Six Sigma is their fusion, which is termed Lean Six Sigma (LSS). While understanding the requirement to deliver business value to the consumer in a rapidly changing environment and considering the demands of end-users into account, the integration of Lean development and Six Sigma seems to be a promising endeavour and has received increasing attention in recent years [125].

8.3 Lean Construction

In the broader construction industry, lean construction is employed as a continuous process of improving construction projects through the elimination or reduction of waste and to meet or even exceed client requirements [126].

The application of lean construction in the construction industry contributes to eliminating non-value-adding activities in the construction process while increasing value-adding activities [31].

Conceptually, lean construction is rooted in lean operations in the field of operations management. The objective of lean production is to decrease the waste inherent in converting physical inputs into outputs in the production process.

Similarly, lean construction is, therefore, a way to design production systems in building construction to minimize waste of materials, time, and effort to generate the maximum possible value. Thus, the value generated through the application of lean construction occurs during the project delivery process and is often referred to as lean project delivery. Lean project delivery pursues three goals. First, transform inputs to outputs and make the production realized more efficiently. Second, to ensure the flow of materials, composed of transformation, inspection, moving, and waiting, to eliminate waste (or non-value-adding activities). Third, to create value for the client by fulfilling his/her objectives. These goals are complementary and should be integrated into implementing lean construction [35].

8.4 Lean Six Sigma Impact on Risks in the Construction Industry

The intensity of the pursuit for the operational application of lean tools in the construction projects is on the increase; this is due to the realization by construction companies of the potentials of an effective lean project development process in improving project completion time, engineering hours, design and supply chain management integration, ease in constructability, environmental sustainability, flexibility, process control, and increased in the quality of new projects. The conventional approaches to construction are considered not suitable for managing projects with complexity [127]. It is an undeniable fact that the lean tools adoption in construction projects is very significant for delay control [128].

8.5 Key Lean Construction Management Tools

Considering the significance of lean implementation in the construction project development, a number of studies have been conducted over the years to develop, advance or improve techniques, methods, models and approaches for lean construction development practices and for organizational leanness. Through the preliminary analysis, forty tools were endorsed by experts. To be able to select the relevant tools for the high priority risks to be identified, a brief description is introduced, along with tool scope and key benefits [128].

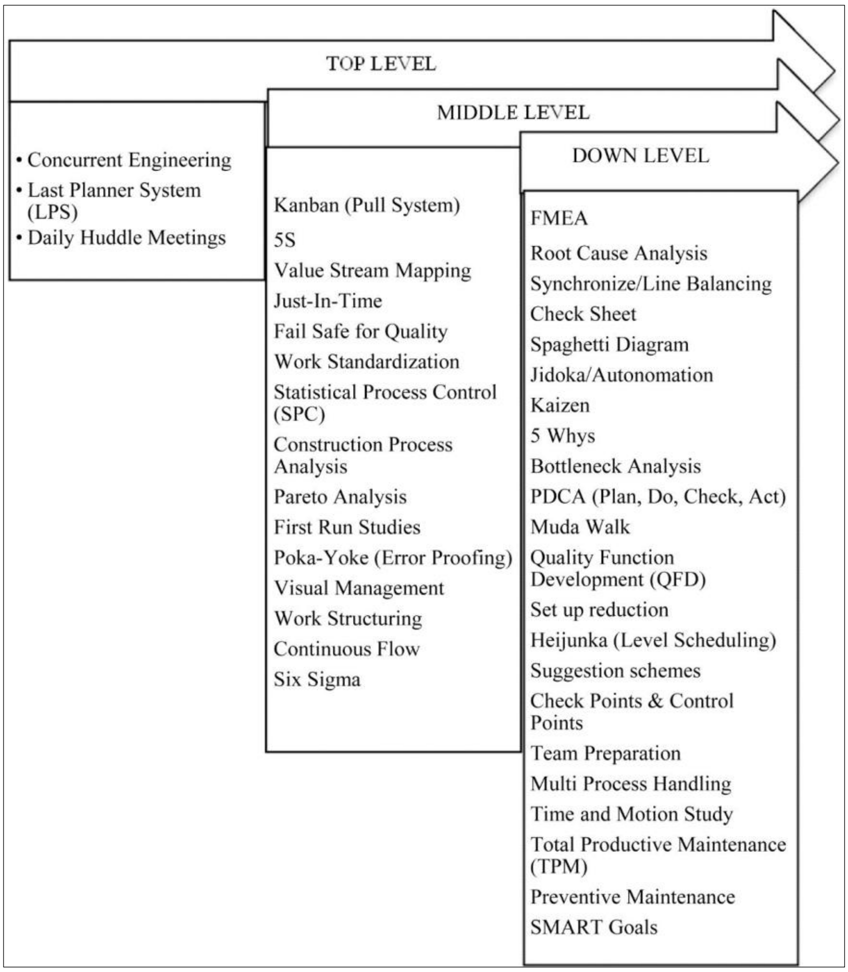


Figure 8.1: Lean Construction Tools [128]

Table 8.1: Brief of the 40 Lean Tools [128]

n	Tool	Description	Scope / Key Benefit
1.	Fail Safe for Quality	Relies on the generation of ideas that alert for potential defects.	Early Detection of Product Defects
2.	Construction Process Analysis	Construction process analysis implements process charts and top-view flow diagrams common among process analysis techniques	Study each step by drawing a layout of the area in which a process flow.
3.	5S	Five related terms, beginning with an S sound, describing workplace practices conducive to visual control and lean production.	Workplace Organization and Discipline
4.	Work Structuring	The development of operation and process design in alignment with product design, the structure of supply chains, the allocation of resources, and design-for-assembly efforts"	Making work flow more reliable and quicker while delivering value to the customer
5.	Statistical Process Control (SPC)	The use of statistical techniques to control a process or production method	Minimize Process Variation
6.	Concurrent Engineering	A method of designing and developing products, in which the different stages run simultaneously, rather than consecutively.	Decreases product development time and also the time to market
7.	Muda Walk	Identification of any activity that consumes resources without creating value for the customer.	Waste Reduction
8.	5 Whys	The practice of asking why repeatedly whenever a problem is encountered in order to get beyond the obvious symptoms to discover the root cause.	Root Cause Analysis
9.	Synchronize/Line Balancing	The capability of an assembly line to be balanced even when production volume fluctuates up or down.	Productivity Improvement
10.	Heijunka (Level Scheduling)	Levelling the type and quantity of production over a fixed period of time.	Enables production to efficiently meet customer demands while avoiding batching
11.	Failure Mode and Effects Analysis (FMEA)	A structured and qualitative analysis of a system or function which identifies potential system failure modes, their causes and the effects on the system operation associated with the failure mode's accuracy	Ranking Failures / Risks
12.	Team Preparation	Each touch labor employee ultimately will need to be capable of operating every process within the cell.	Production Flexibility
13.	SMART Goals	SMART Goals are goals that are: Specific, Measurable, Attainable, Relevant, and Time-Specific.	Translate Goals into Quantifiable Forms
14.	Total Productive Maintenance (TPM)	Total Productive Maintenance is a holistic approach to maintenance that focuses on proactive and preventative maintenance. TPM blurs the distinction between maintenance and production by placing a strong emphasis on empowering operators to help maintain their equipment.	Maximize the operational time of equipment.
15.	Time and Motion Study	Direct and continuous observation of a task, using a timekeeping device to record the time taken to accomplish a task	Time Study of a Process
16.	Value Stream Mapping	A simple diagram of every step involved in the material and information flows needed to bring a product from order to delivery.	Planning for Improvement

n	Tool	Description	Scope / Key Benefit
17.	Just-In-Time	A simple diagram of every step involved in the material and information flows needed to bring a product from order to delivery.	Elimination of Production Waste
18.	First Run Studies	Trial execution of a process in order to determine the best means, methods, sequencing, etc. to perform it.	Process Design
19.	Pareto Analysis	Plotting the number of instances attributable to a specific cause against the number of total instances	determine the primary culprits—the "vital few," responsible for the majority of the effects
20.	Continuous Flow	Producing and moving one item at a time (or a small and consistent batch of items) through a series of processing steps as continuously as possible, with each step making just what is requested by the next step	Waste Elimination
21.	Last Planner System (LPS)	Management of construction process, and continuous monitoring of the planning efficiency, to assist in developing foresight, smoothing workflow variations, and reducing/removing uncertainties plaguing construction processes.	Improved productivity, improved collaboration, reduced risk, and provided benefits to projects of all scales, scopes and complexities.
22.	Check Sheet	A check sheet is a structured, prepared form for collecting and analysing data.	Data Analysis
23.	Kaizen	Continuous improvement of an entire value stream or an individual process to create more value with less waste.	Elimination of Waste
24.	FIFO line (First In, First Out)	The principle and practice of maintaining precise production and conveyance sequence by ensuring that the first part to enter a process or storage location is also the first part to exit.	This ensures that stored parts do not become obsolete and that quality problems are not buried in inventory
25.	Set up reduction	The process of reducing the amount of time needed to changeover a process from the last part for the previous product to the first good part for the next product.	Improve Production Flexibility
26.	Bottleneck Analysis	The Process Bottleneck Analysis tool helps a team identify process steps where flow is constrained, find the root causes of those constraints, and address the root causes that have been identified.	Productivity Improvement
27.	Suggestion schemes	a system in which employees or customers are asked to suggest ways in which an organization can improve its products or services, the way it operates, etc.	Improving Morale, Process Improvement
28.	Multi Process Handling	The work practice of assigning operators to operate more than one process in a product-flow oriented layout.	Improve Production Flexibility
29.	Check Points & Control Points	Identification and Management of Key Product and Process Key Parameters	Quality Control
30.	Preventive Maintenance	An equipment servicing approach considered a precursor to Total Productive Maintenance that is based on regularly scheduled checking and overhauling by maintenance personnel	decrease breakdowns and increase equipment life.
31.	Kanban (Pull System)	A kanban is a signalling device that gives authorization and instructions for the production or withdrawal (conveyance) of items in a pull system. The term is Japanese for “sign” or “signboard.”	Management of Process Flow

n	Tool	Description	Scope / Key Benefit
32.	Work Standardization	Standard work is a tool that defines the interaction of people and their environment when processing a repetitive product or service.	Preventing backsliding and giving the necessary standard, or basis, for improvement.
33.	Visual Management	Visual Management is defined as the placement in plain view of all tools, parts, production activities, and indicators of production system performance, so the status of the system can be understood at a glance by everyone involved.	Increasing transparency, improving communication on construction sites
34.	Poka-Yoke (Error Proofing)	Methods that help operators avoid mistakes in their work caused by choosing the wrong part, leaving out a part, installing a part backwards	Elimination of Defects
35.	Six Sigma	Six Sigma, inhibits the process variation on priority by imparting the entire process towards mean	Elimination of Defects
36.	Daily Huddle Meetings	A daily huddle is a quick but effective communication tool to keep team on track to meet their weekly goals	Improve Communication
37.	Root Cause Analysis	Root cause analysis (RCA) is the process of discovering the root causes of problems in order to identify appropriate solutions.	Identification of problem causes and best practical Solutions
38.	PDCA (Plan, Do, Check, Act)	PDCA is an improvement cycle based on the scientific method of proposing a change in a process, implementing the change, measuring the results, and taking appropriate action.	Achieve continuous improvement and respond to different business challenges
39.	Jidoka/Automation	Providing machines and operators the ability to detect when an abnormal condition has occurred and immediately stop work.	Waste Elimination
40.	Quality Function Development (QFD)	Quality Function Deployment (QFD) is a process and set of tools used to effectively define customer requirements and convert them into detailed engineering	Product Design

8.6 Lean Six Sigma Approach to Prioritizing Risk Factors

Of the forty identified tools, two key Lean Six Sigma Concepts are relevant to the scope of Prioritizing Risk Factors; Failure Mode and Effect Analysis (FMEA) and Pareto Analysis. Then, each tool is applied to the survey results to derive the risk priorities. [129]

8.6.1 Failure mode and effect analysis (FMEA)

In Lean Six Sigma, FMEA is used as a structured and qualitative analysis of a system or function which identifies potential system failure modes, their causes and the effects on the system operation associated with the failure mode's accuracy [129].

FMEA is a reliable method in the field of risk management for guaranteeing product and system (design and operations) reliability and safety in various industries. The method can be used to effectively determine the possible element failures and errors of a process, system, or design structure. The major objectives of using FMEA are to identify potential failure modes in the system units, evaluate their subsequent effects on system performance, and consequently recommend strategies for eliminating or reducing the chance of Occurrence or severity and increasing the detectability of the particular failure mode.

The favourable applicability of FMEA has resulted in its application to many studies and practical situations pertaining to risk assessment and system safety enhancement [130].

Conventionally, FMEA is a method for prioritizing the failure modes on the basis of the risk priority number (RPN). To obtain the RPN score, one can simply multiply three RPN elements that are typically ranked on a scale of ten, namely the severity of the failure effect (S), probability of failure-mode Occurrence (O), and probability of the failure being detected (D); that is, $RPN = S \times O \times D$ [131].

8.6.2 Identifying Risk Priority Number for Identified Construction Risk Categories

This section uses the survey results to quantify the risk priority number for each risk category (Construction Mismanagement Risks, Legal Risks, Financial Risks, etc). The three components of the Risk Priority Number (RPN) were derived from the survey results as follows: Severity, Occurrence and Detection

Severity: severity score is calculated based on the score given for Risk Impact on Cost, Delay and Impact on other Risk Categories as per the survey form.

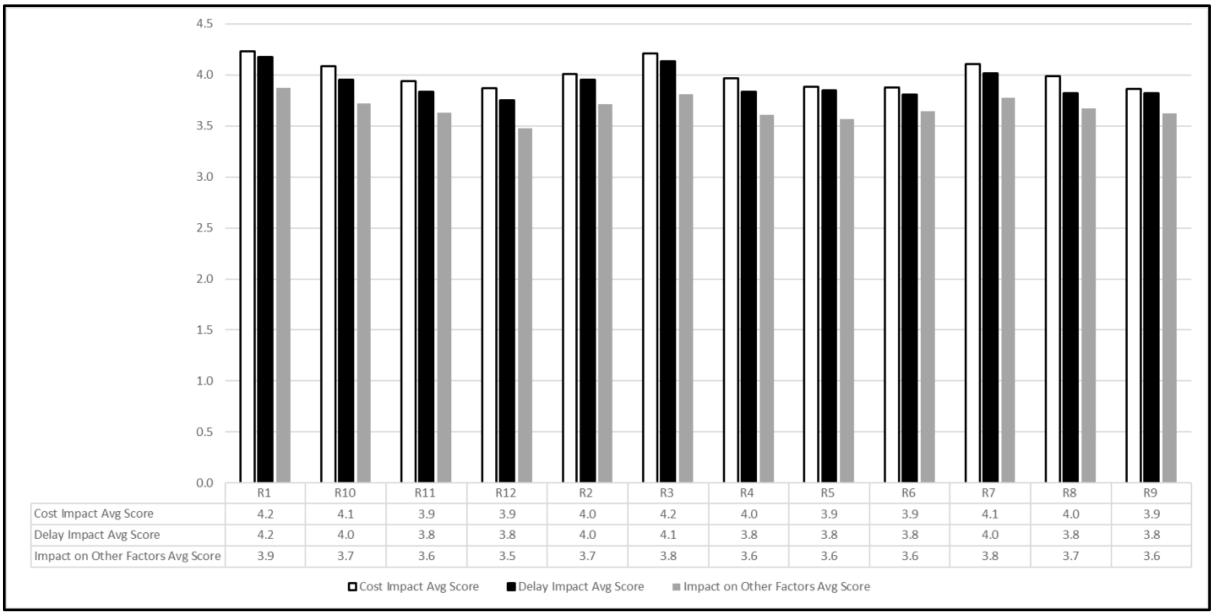


Figure 8.2: Risk Impact by Category [source: own study]

Then, each risk category is given a Severity Ranking from 10 (most severe), to 1 (lowest severe), based on ranking given by the survey from (Very strong to Very Low Impact). The following equation is developed to convert the survey impact voting to Severity Score on a scale of Ten;

$$S_s = \frac{C_s + D_s + F_s}{3N} \times \frac{10}{5}$$

Where:

S_s: Severity Score

C_s: Cost Score

D_s: Delay Score

F_s: Other Factors Score

N: of Number Respondents

The severity ranking is summarized as follows:

Risk	Risk Category	S_s
R1	Construction Mismanagement Risks	8.2
R3	Financial Risks	8.1
R7	Technical Risks	7.9
R10	Risks in the mismanagement of quality	7.8
R2	Communication Risk	7.8
R8	Risks of Design	7.7
R4	Legal Risks	7.6
R11	Safety Risks	7.6
R6	Policy and Politics Risks	7.6
R9	Human Resources Risks	7.5
R5	Market Risks	7.5
R12	Health Risks	7.4

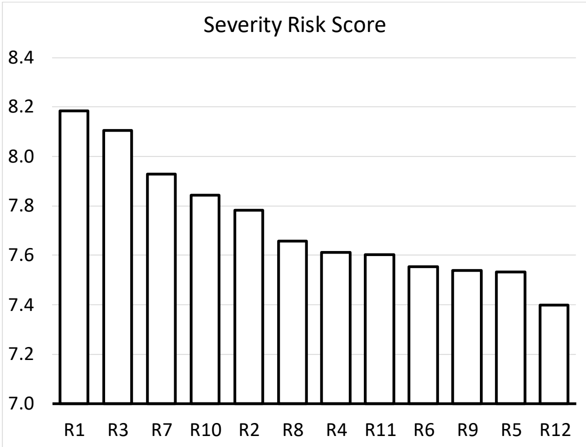


Figure 8.3: Severity Risk Score [source: own study]

- **Occurrence**: Occurrence score is calculated based on the score given for Risk Frequency assigned by the survey. Then, each risk category is given a Frequency Ranking from 10 (Highest Occurrence), to 1 (lowest Occurrence), based on ranking given by the survey from (Very high to Very few Frequency).

The following equation is used to convert survey result to Occurrence Score;

$$O_s = \frac{F_s}{N} \times \frac{10}{5}$$

Where:

O_s: Occurrence Score

F_s: Frequency Score

N: Number of Respondents

The occurrence ranking is summarized as follows:

Risk	Risk Category	O_s
R1	Construction Mismanagement Risks	7.8
R3	Financial Risks	7.7
R2	Communication Risk	7.5
R7	Technical Risks	7.4
R10	Risks in the mismanagement of quality	7.3
R6	Policy and Politics Risks	7.2
R4	Legal Risks	7.2
R5	Market Risks	7.2
R8	Risks of Design	7.1
R11	Safety Risks	7.1
R9	Human Resources Risks	7.0
R12	Health Risks	6.9

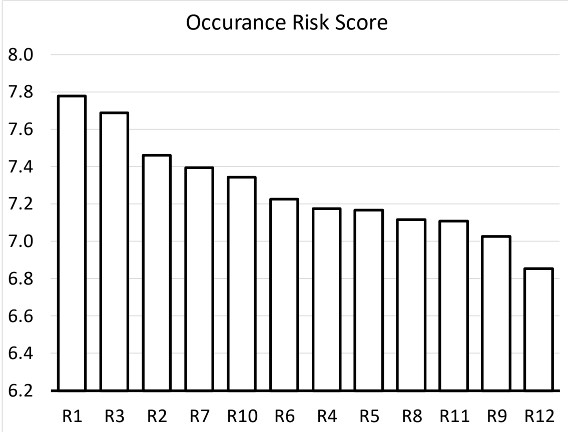


Figure 8.4: Occurrence Risk Score [source: own study]

- **Detection**: To determine whether it is possible to detect risks in the initial stages of the project, a supplementary questionnaire was developed for experts. The questionnaire included a group of 12 experts, who were originally identified in the interviews that were explained in Chapter Seven of this thesis, where they were asked directly about the possibility of detecting the identified risks. Originally, this was done by directing the question to each expert for each risk category and asking to rate the risk detection of the risk within the limits. The detection score is calculated based on the score given for Risk Detectability assigned by the surveyed experts. Then, each risk category is given a Detection Ranking from 10 (Highest Probability of Detection) to 1 (lowest probability of Detection), based on the ranking given by the survey shown in Appendix **(F)**. The detection score is calculated using the following formula.

$$D_s = \frac{d_s}{N}$$

Where:

D_s: Detection Score

ds: Individual detection survey score

N: Number of Respondents

The Detection ranking is summarized as follows:

Risk	Risk Category	D_S
R1	Construction Mismanagement Risks	6.9
R4	Legal Risks	6.4
R9	Human Resources Risks	6.2
R8	Risks of Design	6.1
R12	Health Risks	5.7
R3	Financial Risks	5.5
R11	Safety Risks	5.5
R7	Technical Risks	5.2
R2	Communication Risk	5.1
R6	Policy and Politics Risks	4.9
R10	Risks in the mismanagement of quality	4.7
R5	Market Risks	4.2

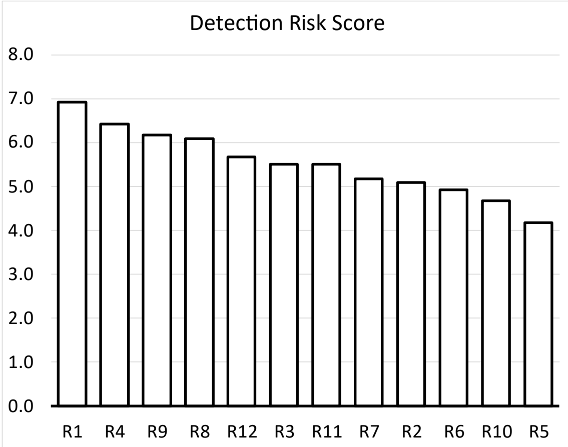


Figure 8.5: Detection Risk Score [source: own study]

After the calculation of the Severity, Occurrence and Detection Scores, the next step is to calculate the Risk Priority Number Score. RPN Score is the product of Severity, Occurrence, and Detection and is calculated using the formula:

$$RPN = S_S \times O_S \times D_S$$

Where:

RPN: Risk Priority Number

S_S: Severity Score

O_S: Occurrence Score

D_S: Detection Score

and summarized as follows:

Table 8.2: FMEA Table - Risk Effects are based on highest score in the Risk Impact by Category Figure [source: own study]

Risk	Risk Category	Potential Risk Effects (Y's)	Risk Factors (X's)	S_s	O_s	D_s	RPN
R1	Construction Mismanagement Risks	Cost Impact	Lack of planning and management Lack of scope clarity or changes to the projects' scope and cost Poor management Inadequate Site planning and management Delay in making decisions	8.2	7.8	6.9	440
R4	Legal Risks	Cost Impact	Contractual Weakness Terrorism and Sabotage Inconsistencies and mistakes in contract documents Changes in the applicable law	7.6	7.2	6.4	350
R3	Financial Risks	Delay Impact	Financial problems of the client Financial problems of the contractor Delaying or refusing payments to contractors, subcontractors or workers External economic factors (fluctuations of prices and interest rates, inflation, recession)	8.1	7.7	5.5	343
R8	Risks of Design	Cost Impact	Errors in Design or changes Design and drawing flaws Inadequate architecture design	7.7	7.1	6.1	331
R9	Human Resources Risks	Delay Impact	Insufficient number/lack of workers Insufficient number/lack of qualified personnel	7.5	7.0	6.2	327
R7	Technical Risks	Delay Impact	Variation Works/Change order Unforeseen ground conditions (lack of site investigation) Time underestimation (inadequate time)	7.9	7.4	5.2	303

Risk	Risk Category	Potential Risk Effects (Y's)	Risk Factors (X's)	S_s	O_s	D_s	RPN
R11	Safety Risks	Cost Impact	Lack of Safety in construction Delays due to Incompetence, or lack of experience of workers Random events (e.g., accidents)	7.6	7.1	5.5	297
R2	Communication Risk	Cost Impact	Poor communication with client/Imprecise expectation Poor communication between the parties	7.8	7.5	5.1	295
R12	Health Risks	Delay Impact	Low productivity of the workers (poor working conditions, low morale) Bad weather or climate conditions	7.4	6.9	5.7	287
R10	Risks in the mismanagement of quality	Delay Impact	Reworks due to poor quality or flaws in execution Poor quality or damage of building material	7.8	7.3	4.7	269
R6	Policy and Politics Risks	Cost Impact	Excessive bureaucracy Delays due to complex political situation	7.6	7.2	4.9	268
R5	Market Risks	Delay Impact	Transportation and logistics Lowest bidding procurement method Delays in the delivery of materials	7.5	7.2	4.2	225

8.6.3 Pareto Analysis

Vilfredo Pareto was a 19th-century economist who studied the distribution of wealth and income in Italy then. His research uncovered that most of the wealth was held by relatively few citizens while the great majority of the population lived in poverty. Pareto developed logarithmic mathematical models to describe this non-uniform distribution of wealth, and mathematician M.O. Lorenz developed graphs to illustrate it [151].

Pareto's research created a template for measuring cause and effect. When Dr. Joseph Juran sought a short-hand term to describe how relatively few causes often account for a great majority of effects, he remembered Pareto's discovery and dubbed this phenomenon the Pareto principle. A common way to describe the Pareto Principle, is that 80% of the outcomes result from 20% of the causes – or in simple terms – 20% of your actions/activities will produce 80% of your results/effects. This principle can be applied to a wide variety of situations in both the business world and the real world. By plotting the number of instances attributable to a specific cause against the number of total instances, you can determine the primary culprits—the "vital few," as Dr. Juran called them—responsible for the majority of the effects [132].

8.6.4 Using Pareto Analysis to Identify Risk Categories Ranking & Contribution

Pareto analysis is used to Rank Risks by FMEA's RPN Score and the Risk Priority Number's components.

Percent is calculated using the Following Formula

$$Percent_i = \frac{RPN_i}{\sum_{12}^{i=1} RPN_i}$$

And the cumulative percent is calculated using the following formula

$$Cum = \sum_{12}^{i=1} Percent_i$$

The highest risk RPN score is for Construction Mismanagement Risks, contributing 11.8% to total Risks, followed by Legal Risks at 9.4% and Financial Risks at 9.2%.

Risks R1, R4, and R3 are the top three risk categories, while the lowest three risk categories are (R10, R6 & R5)

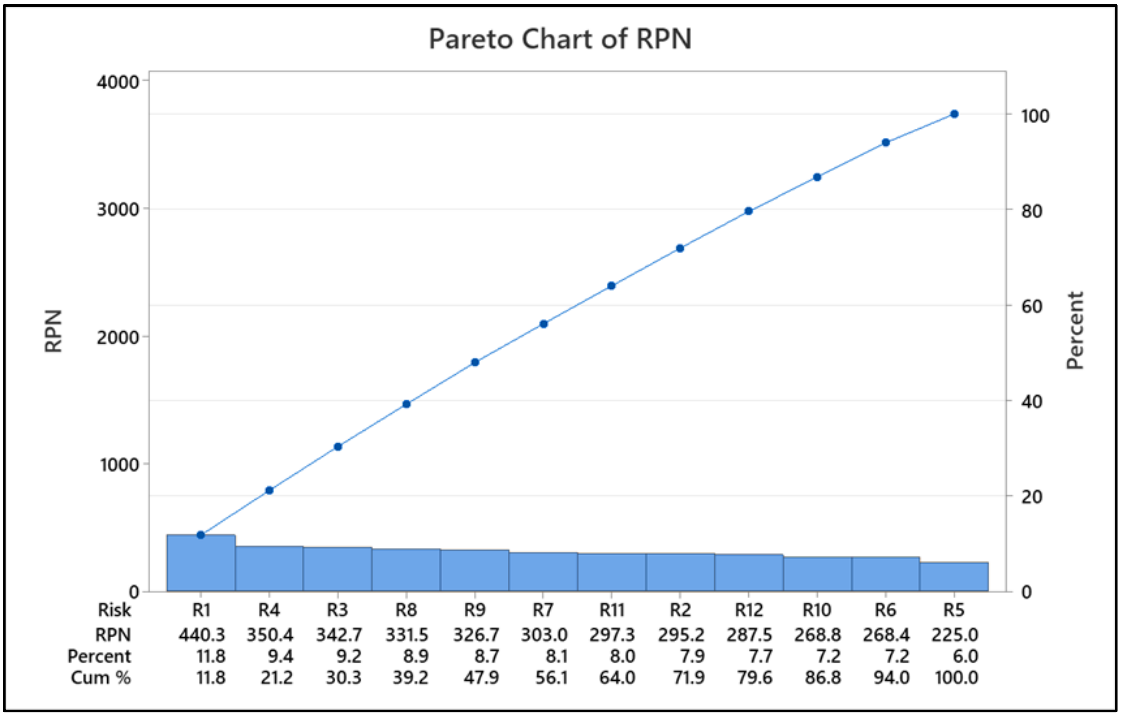


Figure 8.6: Pareto Chart of Risks according to RPN [source: own study]

Based on the Pareto's principle, as previously explained, this can be applied on this study by identifying the risks that contribute to 80% of the RPN values.

From this standpoint, the first nine risk groups from the Pareto classification were selected, which constitute 80% of the total risks expected to occur in the project, as illustrated in Figure 8.7. Therefore, the target risk categories and their subsequent factors would be R1, R4, R3, R8, R9, R7, R11, R2 and R12, respectively.

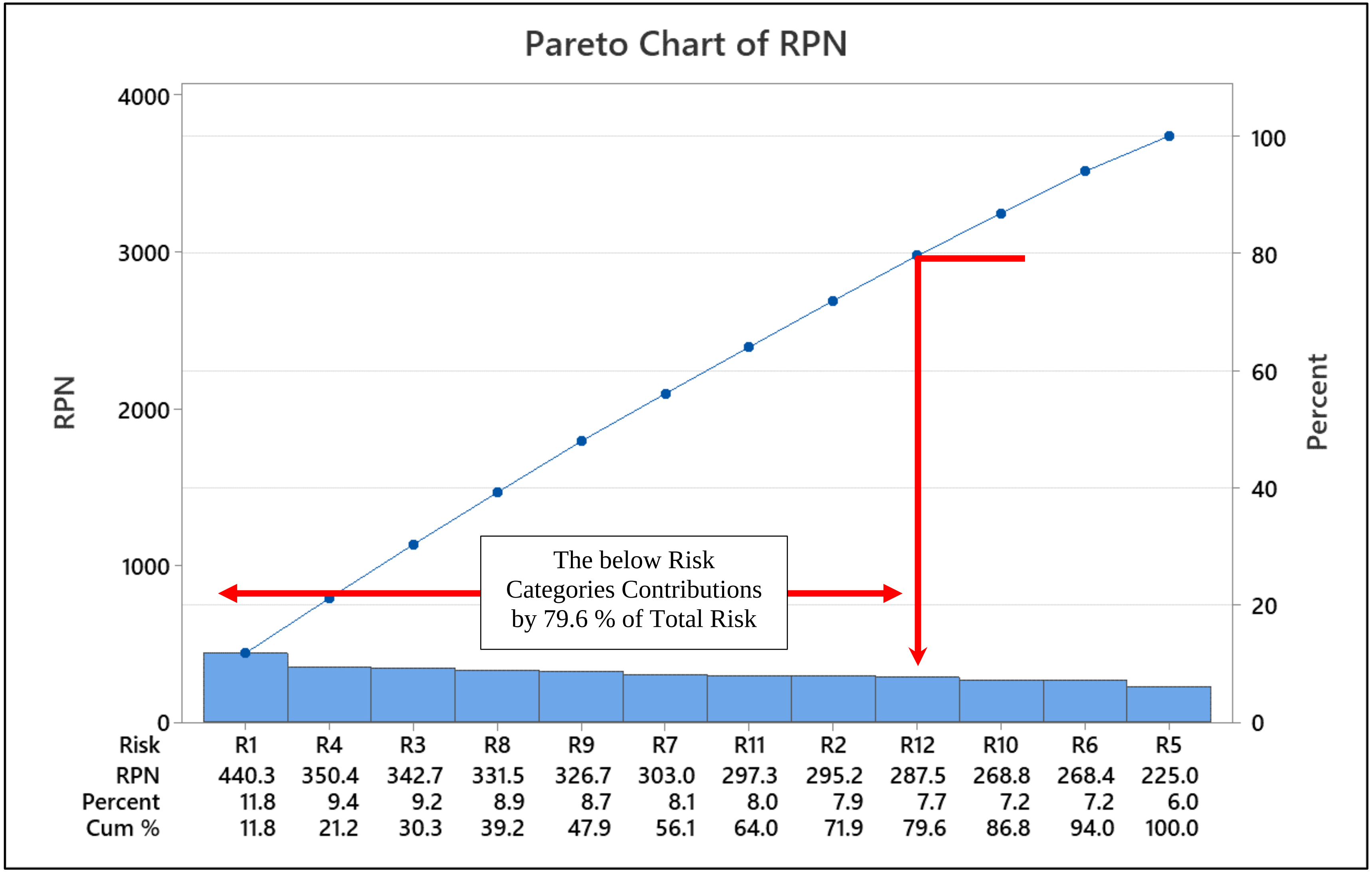


Figure 8.7: Pareto Chart of Risks according to RPN [source: own study]

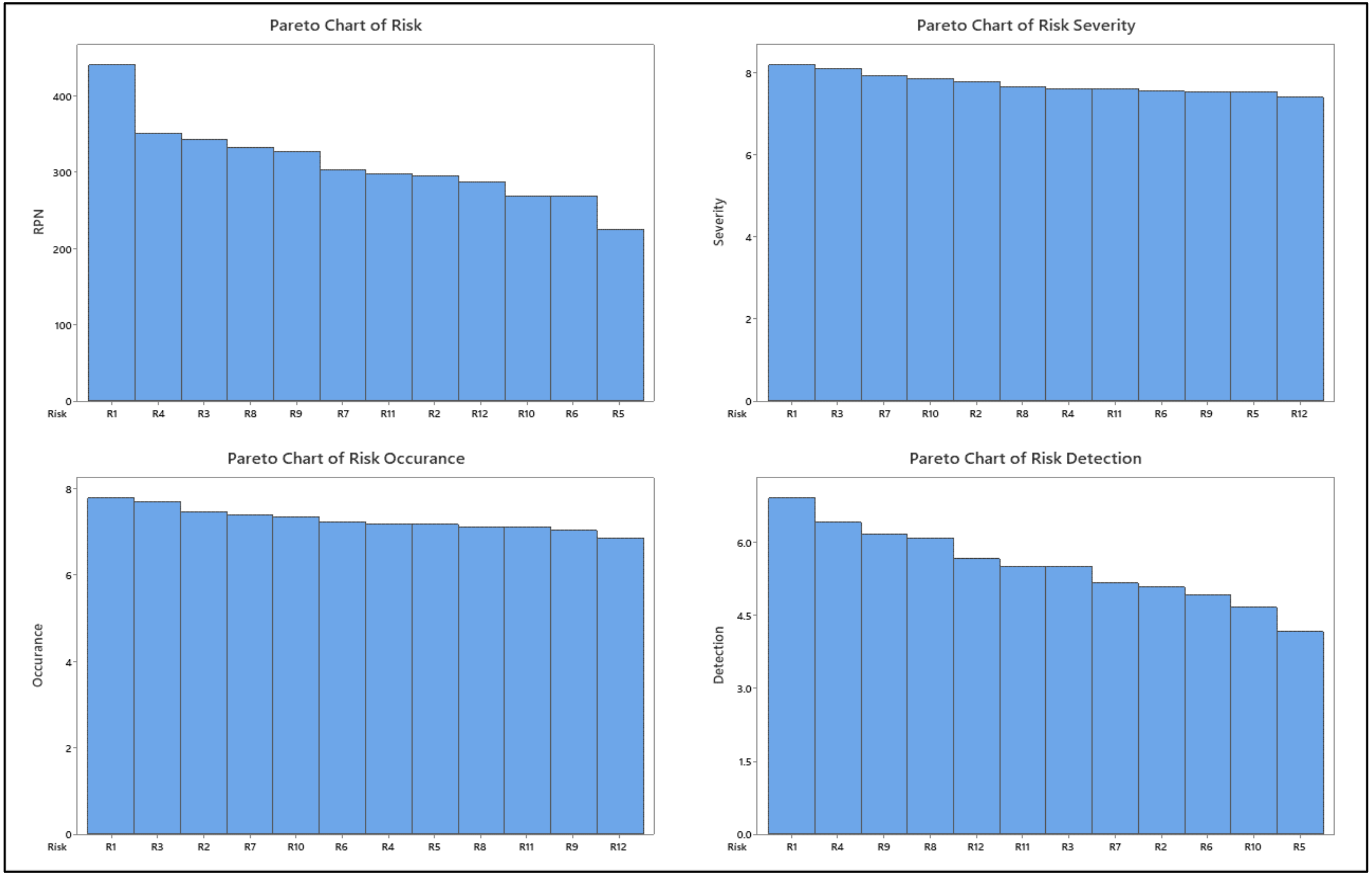


Figure 8.8: Combined Pareto Chars, Showing Arranged Risks by RPN, Severity, Occurrence & Detection Respectively [source: own study]

8.7 Selection of Lean Six Sigma Tools Relevant to Identified target Risk Factors

As the study scope covers risk factors contributing to 80% of total RPN, a set of relevant Lean Six Sigma tools are selected, based on the associated scope and benefits mentioned in the 40 Lean Tools briefing, to target the below risk factors:

Table 8.3: Target Risk Categories and Factors [source: own study]

Risk Category	Risk Factors
Construction Mismanagement Risks	Lack of planning and Management
	Lack of scope clarity or changes to the projects' scope and cost
	Poor Management
	Inadequate Site planning and Management
	Delay in making decisions
Legal Risks	Contractual Weakness
	Terrorism and Sabotage
	Inconsistencies and mistakes in contract documents
	Changes in the applicable law
Financial Risks	Financial problems of the client
	Financial problems of the contractor
	Delaying or refusing payments to contractors, subcontractors or workers
	External economic factors (fluctuations of prices and interest rates, inflation, recession)
Risks of Design	Errors in Design or changes
	Design and drawing flaws
	Inadequate architecture design
Human Resources Risks	Insufficient number/lack of workers
	Insufficient number/lack of qualified personnel
Technical Risks	Variation Works/Change order
	Unforeseen ground conditions (lack of site investigation)
	Time underestimation (inadequate time)
Safety Risks	Lack of Safety in construction
	Delays due to Incompetence, or lack of experience of workers
	Random events (e.g., accidents)
Communication Risk	Poor communication with client/Imprecise expectation
	Poor communication between the parties
Health Risks	Low productivity of the workers (poor working conditions, low morale)
	Bad weather or climate conditions

Table 8.4: Risk-Lean Tools Matrix [source: own study]

R	Risk Factors	Lean Design Management (LPS)	Standard Work	PDCA	Visual Management	Suggestion Schemes
R1	Lack of planning and Management			x	x	
R1	Lack of scope clarity or changes to the projects' scope and cost	x		x	x	
R1	Poor Management			x		
R1	Inadequate Site planning and Management			x	x	
R1	Delay in making decisions	x		x	x	
R4	Contractual Weakness		x	x		
R4	Terrorism and Sabotage			x		
R4	Inconsistencies and mistakes in contract documents			x		
R4	Changes in the applicable law			x		
R3	Financial problems of the client			x		
R3	Financial problems of the contractor			x		
R3	Delaying or refusing payments to contractors, subcontractors or workers			x		
R3	External economic factors (fluctuations of prices and interest rates, inflation, recession)			x		
R8	Errors in Design or changes	x		x		
R8	Design and drawing flaws	x		x		
R8	Inadequate architecture design			x		
R9	Insufficient number/lack of workers		x	x		
R9	Insufficient number/lack of qualified personnel			x		
R7	Variation Works/Change order	x		x	x	
R7	Unforeseen ground conditions (lack of site investigation)			x	x	
R7	Time underestimation (inadequate time)		x	x	x	
R11	Lack of Safety in construction			x	x	
R11	Delays due to Incompetence, or lack of experience of workers		x	x		
R11	Random events (e.g., accidents)			x	x	
R2	Poor communication with client/Imprecise expectation	x		x	x	
R2	Poor communication between the parties	x		x	x	
R12	Low productivity of the workers (poor working conditions, low morale)		x	x		x
R12	Bad weather or climate conditions		x	x		

The table above shows the researcher's tools selected from of Lean Six Sigma tools list that the target risk factors and their corresponding for the 9 categories determined by the RPN percentage.

8.8 The selected Lean Six Sigma tools of the study

For each selected Lean Six Sigma tool, this section will introduce a briefing of each tool, where it can be applied to minimize risks, and the key guidelines for use.

8.8.1 Lean product development and design management using LPS

8.8.1.1 Definition

Design management is an element of the product development process focused on organizing the design team and understanding its nature, stages, and activities, aiming to support communication, coordination and improving the integration of information flows.

Lean Construction research has proposed the use of diverse approaches to support product development and Design, in recognition of its essential role in providing value to customers [133].

Design management in Lean Construction realizes its principles through applying tools and techniques to support a specific design activity or part of the product development process, promoting Lean principles such as collaboration, efficiency, and waste reduction.

The Last Planner System (LPS) was developed for the AEC industry by Greg Howell and Glenn Ballard independent of any knowledge of Toyota or Lean. However, its principles align well with Lean principles including Responsibility Based Planning and Control [134]. The application of LPS in Design and construction has increased productivity, improved collaboration, reduced risk, and provided benefits to projects of all scales, scopes and complexities. These benefits have made the Lean production model valued and widely accepted and adopted in the construction phases.

Survey findings of construction industry clients by McGraw-Hill Construction in 2013 support this assessment:

- 84% found that adopting Lean has led to higher quality projects.
- 80% report greater customer satisfaction.

Anecdotal evidence also supported this conclusion – Many LCI Conference presentations have documented the successful application and benefits of LPS for project management and delivery [135].

8.8.1.2 Applications

- **Construction Mismanagement Risks**

Lean product development and design management improves planning and control, especially at early design stages

- **Risks of Design**

Lean product development and design management improve collaboration and integration between design teams

It helps with the identification of customers' needs and its translation into requirements and product specifications

It facilitates considering and balancing multiple stakeholders' needs and goals, which are often conflicting

- **Technical Risks**

Lean product development and design management help with Minimizing and or early identification of Design errors and miscommunication, which leads to the reduction of rework

- **Communication Risk**

Lean Product development and design management minimizes miscommunication and improves coordination between stakeholders and it improves shared understanding between teams.

8.8.1.3 Guidelines

Coordinating between interdependent players is a key issue in planning work. The Design Phases of a project involve a remarkably diverse group, end users, executive leadership, the construct team, and the design team. The design team itself is diverse. On a major project there may be 15 to 20 disciplines, owner groups and Authorities Having Jurisdictions represented. The following guidelines apply to Design Phases [136].

Table 8.5: LPS Guidelines [136]

Guideline	Key Dimensions	Lean Principles
Give visibility to processes and outcomes	• Systems should be intuitive, so as to reduce imaginary complexity. • Visibility should be given to informal work practices, which may encompass either useful innovations or latent hazards that over time may be taken for granted as part of normal work. • However, privacy may be important for adapting and innovating, and these may be hindered if visual Management is used as a means for enforcing the use of ineffective rules.	P2: Create continuous process flow to bring problems to the surface. P5: Build a culture of stopping to fix problems, to get quality right first time. P7: Use visual control so no problems are hidden.
Encourage diversity of perspectives when making decisions	• Diversity of perspectives may help to tackle uncertainty. • Agents involved in decision-making should hold complementary skills. • Some requirements for the implementation of this guideline are: high levels of trust, reduction of power differentials, and identification of apt decision-makers.	P13: Make decisions slowly by consensus, thoroughly considering all options (implement decisions rapidly).
Monitor unintended consequences of improvements and small changes	• The impacts of small changes and improvements may be large in CSS, due to nonlinear interactions. • Improvements and small changes interact between themselves, and this poses opportunities for unintended consequences. • As small changes happen all the time, they offer frequent opportunities for reflection on practice. • Small changes and improvements may be either non-intentional or intentionally self-initiated by the organisation (e.g., through kaizen) as well as originated from external sources (e.g., a client changes its order).	P7: Use visual control so no problems are hidden. P6: Standardised tasks are the foundation for continuous improvement and employee empowerment. P12: Go and see for yourself to thoroughly understand the situations.
Design slack	• Slack means spare resources, of any sort, which can be called on in times of need. Also, slack must cope with variability, thus contributing to the resilience of CSS. Since variability is normal in these systems, slack also tends to be useful in everyday work, rather than only in extreme situations. • Slack may take a number of forms, such as redundant equipment, underutilised space, excess of labour, generous time margins. • Slack may have side effects such as contributing to maintain problems hidden, and disguising small changes.	P3: Use pull systems to avoid overproduction. P4: Level out the workload.
Monitor and understand the gap between work-as-imagined and work-as-done	• It is impossible for standardised operating procedures to cover all situations. CS regards procedures as dynamic, local, and situated constructions, which need adaptation in the face of variability. • This is in contrast with the traditional view of procedures as 'devised by experts (management) to guard against the errors and mistakes of fallible human operators at the sharp end, who are more limited than the experts in their competence' (Hale and Borys, 2013). • Procedures may be of different types (e.g., goal oriented, action oriented) and, for all types, the gap between them and practice should be monitored.	P6, P12

Guideline	Key Dimensions	Lean Principles
Create an environment that supports resilience	• All the previously mentioned guidelines support resilient performance. • As complexity cannot be fully eliminated, agents must have the skills to adapt to it (i.e., resilience skills). • Resilience skills are defined as individual and team skills of any type necessary to fill in the gaps of procedures, in order to maintain safe and efficient operations during both expected and unexpected situations. • The use of resilience skills requires organisational support, such as granting authority to people to self-organise as well as the provision of training.	P1: Base your management decisions on a long-term philosophy, even at the expense of short-term goals. P8: Use only reliable, thoroughly tested technology. P9: Grow leaders who thoroughly understand the work, live the philosophy and teach it to others. P10: Develop exceptional people and teams who follow your company's philosophy. P11: Respect your extended network of partners and suppliers by challenging them and helping them improve. P14: Become a learning organisation through relentless reflection and continuous improvement.

Additional tips for implementation

- The simple act of recording the design process can result in an intentional design process or a firmwide Design Process Guide
- In addition to pulling from back-to-front it may be useful to work front-to-back to clarify the design process.
- Defining the conditions of satisfaction for each milestone is key. Shared, personalized ownership of the milestones is important. Once established the milestones can be moved to establish a more effective sequence or flow.
- The best practice is to identify stakeholders at a very early stage, capture their quantitative and qualitative (emotional) requirements and use this work to test the relative multiple design alternates. This is the model design process used in manufacturing.

8.8.2 Standardized work

8.8.2.1 Definition

Standardization is the essence of lean methods and forms the basis of continuous improvement. The standardized process does involve not only variation minimization but also kaizen activity to be conducted and continuous improvement to be made [137].

Standard work is a tool that defines the interaction of people and their environment when processing a repetitive product or service. By detailing the one "best way/process" we currently know and understand.

It also highlights what is normal and abnormal—preventing backsliding and giving the necessary standard, or basis, for improvement [138].

8.8.2.2 Applications

- **Construction Mismanagement Risks**

When standardized work is implemented, the gap between expected and actual time, resources, and quality is minimized. Also, when expectations are clear, project rework will be minimal.

- **Legal Risks**

Having a contract development reference, which identifies the potential flows for the different business conditions, can help the project stakeholders minimize the Contractual Weakness incidents.

- **Human Resources Risks**

First, standardized work clarifies the required amount of labor in exact terms, which enables the project manager and team to measure labor utilization and efficiency. Also, standardized work can be used as a job instructions tool to train and onboard new workers when employee's turnover is high.

- **Safety Risks**

As mentioned, standardized work can be used to educate the workers about the safety instructions and policy within the project perimeters.

- **Health Risks**

Firms' standards reinforce the working conditions under which worker should be working, hence reducing and containing the potential negative impact on health.

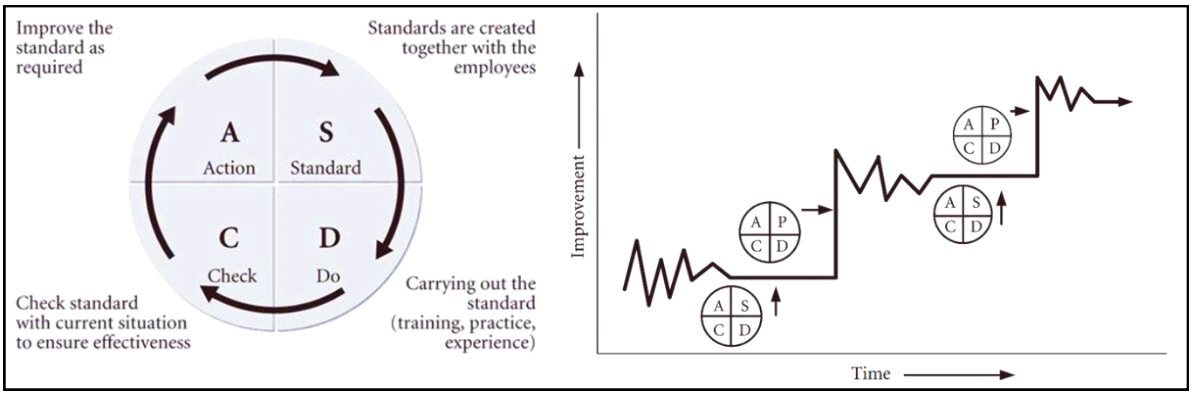


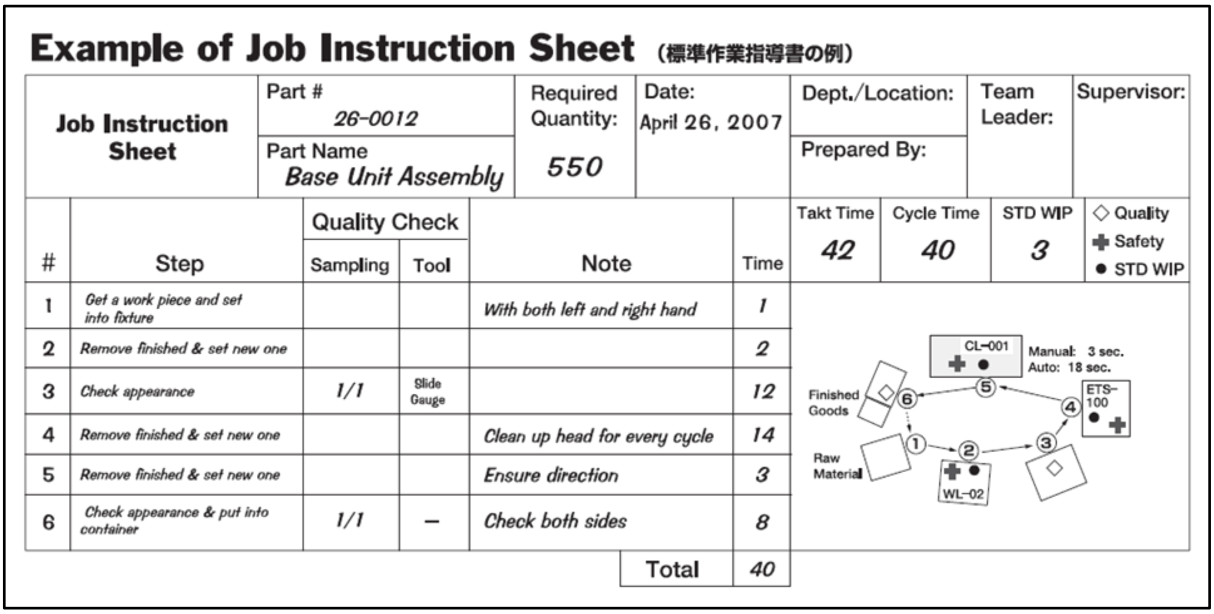
Figure 8.9: Standardize-Do-Check-Act Cycle [137]

8.8.2.3 Guidelines

Within the firm, workers need to follow each detailed standardized procedure that touches every aspect of the firm. At the project level, construction firms need to standardize certain repetitive processes and establish best practice for quality, time, cost, safety practices, etc., so that workers can strictly follow the practice.

One final good point of Toyota's standardization is that it enables the workers to be part of the process of designing and improving the current standards. In terms of construction, this means that the construction firms should provide the freedom to let the project team, including frontline workers, be creative and improve standards (e.g., construction methods of certain processes) [139].

With the continuous improvement mantra, "tomorrow it should be better," the standard work should be revised to incorporate future improvements. (Coimbra)



Example of Job Instruction Sheet (標準作業指導書の例)

Job Instruction Sheet	Part # 26-0012 / Part Name Base Unit Assembly	Required Quantity: 550	Date: April 26, 2007	Dept./Location: / Prepared By:	Team Leader:	Supervisor:

#	Step	Quality Check: Sampling	Quality Check: Tool	Note	Time
1	Get a work piece and set into fixture			With both left and right hand	1
2	Remove finished & set new one				2
3	Check appearance	1/1	Slide Gauge		12
4	Remove finished & set new one			Clean up head for every cycle	14
5	Remove finished & set new one			Ensure direction	3
6	Check appearance & put into container	1/1	–	Check both sides	8
				Total	40

Takt Time	Cycle Time	STD WIP
42	40	3

Figure 8.10: Job Instruction Sheet [156]

8.8.3 Visual Management

8.8.3.1Definition

Visual Management is defined as the placement in plain view of all tools, parts, production activities, and indicators of production system performance, so the status of the system can be understood at a glance by everyone involved [140].

Visual Management (VM) is widely used in advanced manufacturing plants and has been pointed out as one of the fundamental blocks of the lean production philosophy [141].

Within Construction Context, VM is the managerial strategy of consciously integrating visual tools in workspaces with the aim of increasing transparency on construction sites [142].

8.8.3.2 Applications

- **Safety and health Risks**:

The use of VM is important on sites that employ immigrant workers, or a workforce that has a low literacy rate. The value of using culturally suitable audio or visual displays on sites that do not require full competence of a language is highly valuable especially for the communication related to health and safety.

- **Construction Mismanagement Risks:**

Another important application area for VM is production planning and control, mostly connected to the Last Planner System [143]. These include the use of different techniques such as Kanban cards, control panels, performance charts, collaborative process mapping, collaborative construction planning and control model, which is firmly based on the use of VM [135].

- **Communication Risks**

Many studies suggest that alongside presenting a structured and focused meeting mechanism, the team performance boards help facilitate the inter-team communication, engagement and a better work requirement for the project teams [144].

- **Technical Risks**

VM is about making abnormalities visible, stabilizing and improving processes, along with keeping people in contact with the realities of the Workplace [137]. Well-designed VM aids enable managers to simply go-and-see what is happening and anticipate future problems [145].

VM provides information when it is needed in a simple and easy to understand fashion, which in return creates transparency, meaning everyone is working with the same information [146].

- **Human Resources Risks**

Motivational factors for employees like identification of best performed

employees and displaying their achievements in the display boards and making them visible among other employees which encourages others to perform well [147].

8.8.3.3 Guidelines

Starting from the basic approaches to the more advanced VM concepts, different levels of the VM elements identified at the companies were also presented as a VM implementation guide [142].

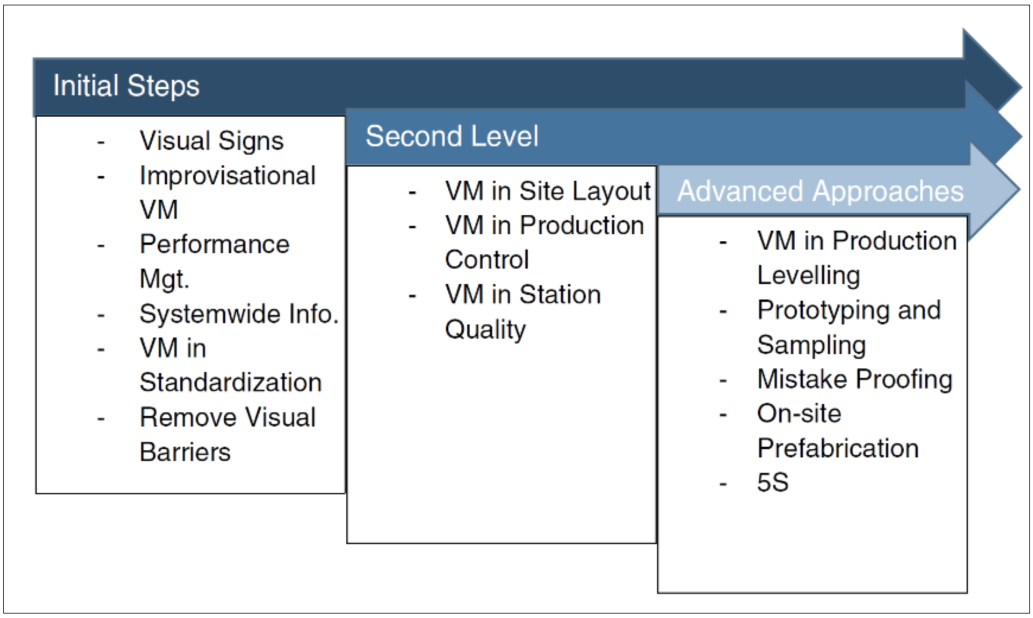


Figure 8.11 Key Guidelines for VM [142]

Examples for the use of Visual Management in a Construction Context can be found below:

Figure 8.12 Visual Workplace in the Big Room at the construction site, Girona, Spain [148].

Visual concrete production leveling example (Brazilian)

Site stock material identification

Figure 8.13 Examples of visual management [160]

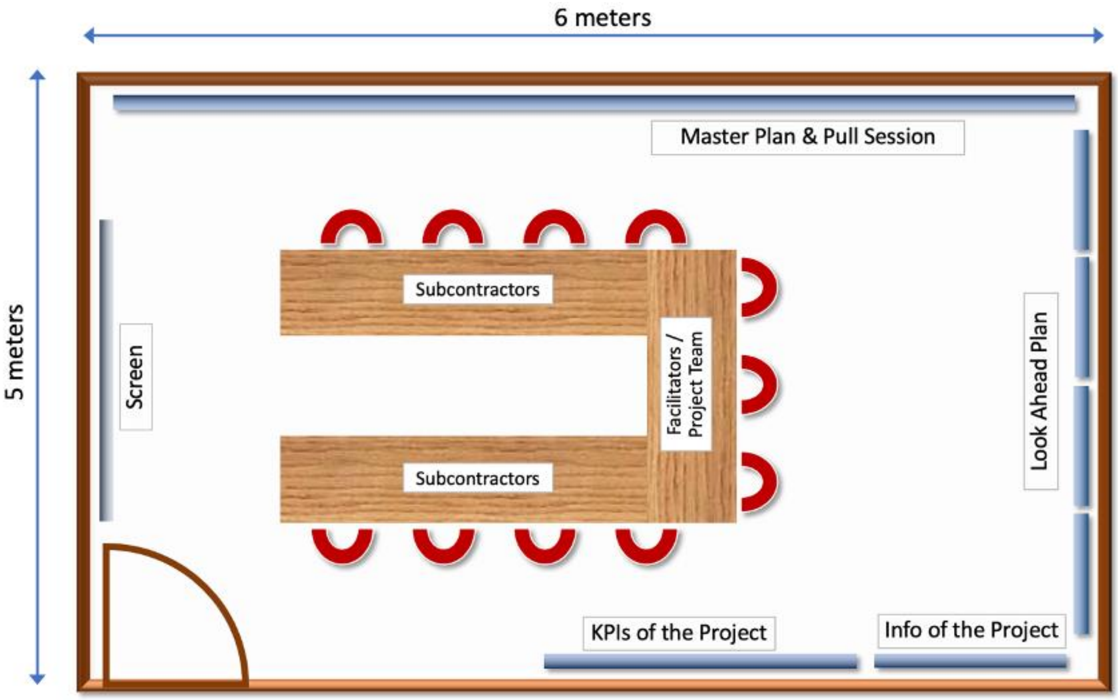


Figure 8.14 Communication Room - Prototype by Juan Felipe Pons [157]

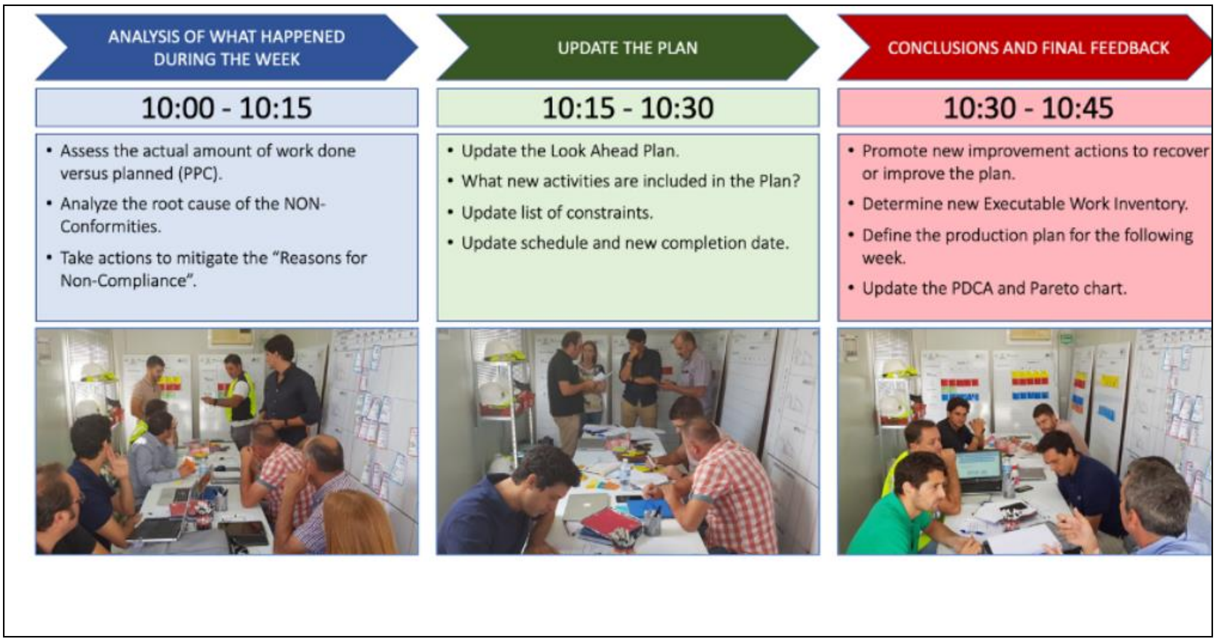


Figure 8.15 Standard Routine for Communication Room Implementation [149]

8.8.4 PDCA, A3 Thinking & Quality Circles

Although several Lean Principles, Concepts, and Tools are available to assist different business challenges, each business and/or industry has unique conditions. In several situations, a project manager or team might not find a best practice solution to adopt from the Lean toolbox, especially when there is no clear causal relationship between the challenge and the contributing factors. In such cases, the project team has to develop and use their problem-solving skills to resolve such challenges. This section introduces the Plan-Do-Check-Act (PDCA) problem-solving methodology and closely related concepts such as A3 thinking and Quality Circles.

8.8.4.1 Definition

PDCA is an improvement cycle based on the scientific method of proposing a change in a process, implementing the change, measuring the results, and taking appropriate action. It also is known as the Deming Cycle or Deming Wheel after W. Edwards Deming, who introduced the concept in Japan in the 1950s.

A3 Thinking is A Toyota-pioneered practice of getting the problem, the analysis, the corrective actions, and the action plan down on a single sheet of large (A3) paper, often with the use of graphics. At Toyota, A3 reports have evolved into a standard method for summarizing problem-solving exercises, status reports, and planning exercises like value-stream mapping. A3 paper is the international term for paper 297 millimetres wide and 420 millimetres long.

The closest U.S. paper size is the 11-by-17-inch tabloid sheet. Quality Control Circle is a small group of workers and their team leader who collectively identify problems in their work area, analyse them, and provide solutions [149].

8.8.4.2 Applications

Problem Solving can assist in overcoming almost all business risk categories as follows:

- **Construction Mismanagement Risks**

Problem solving can help systematically identify the gaps in planning, scope or delays and analyse the situation until the risk is minimized.

- **Legal Risks**

When a project team is faced with a legal issue due to contract or law changes or other factors, the team can identify the root cause(s) and the containment action(s) to minimize the impact of the legal matter, as well as developing a corrective and preventive actions to minimize future incidents and their impact.

- **Financial Risks**

When a project team is faced with financial issues, they can use the root cause analysis to find the causes of the problem and then develop practical corrective and preventive actions to overcome the situation and minimize the future Occurrence and/or impact.

Similarly, PDCA can be used to minimize the Frequency, improve the Detection and reduce the impact of Risks of Design, Human Resources Risks, Technical Risks, Safety Risks, Communication Risks, and other risks categories.

8.8.4.3 Guidelines

The PDCA cycle has four stages:

Plan: Determine goals for a process and needed changes to achieve them.

Do: Implement the changes.

Check: Evaluate the results in terms of performance.

Act: Standardize and stabilize the change or begin the cycle again, depending on the results.

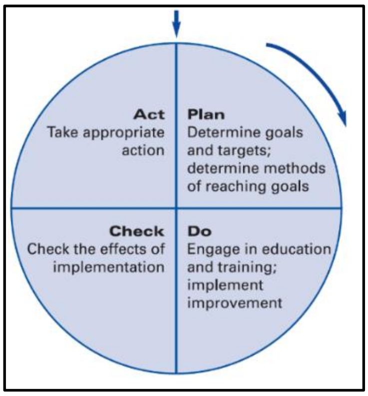


Figure 8.16 The PDCA Cycle [158]

When faced with a gap between the target and current conditions, the Project team can formulate cross-functional Quality Circles and use the A3 Report to apply and document the team activity until the target condition is achieved.

This process of solving problems while creating better employees—A3 analysis—is core to the Toyota management system. An A3 report guides the dialogue and analysis. It identifies the current situation, the nature of the issue, the range of possible counter- measures, the best countermeasure, the means (who will do what when) to put it into practice, and the evidence that the issue has actually been addressed.

Most lean practitioners know "the A3" as a problem-solving process guided by specific steps or questions. The left side of the A3 focuses on various elements of the problem or current condition, and the right on the countermeasures considered, tested, and chosen that resolves the issue or creates a higher standard.

As users record their problem-solving or improvement project's progress, the A3 becomes a storyboard used to facilitate communication, collaboration, and coordination with other stakeholders affected by the goal the A3 owner is working toward (e.g., solving a problem or improving a process). By having all the facts about the effort in one place, logically presented and summarized, the A3 owner is better able to gain buy-in from other stakeholders for recommended process changes [150].

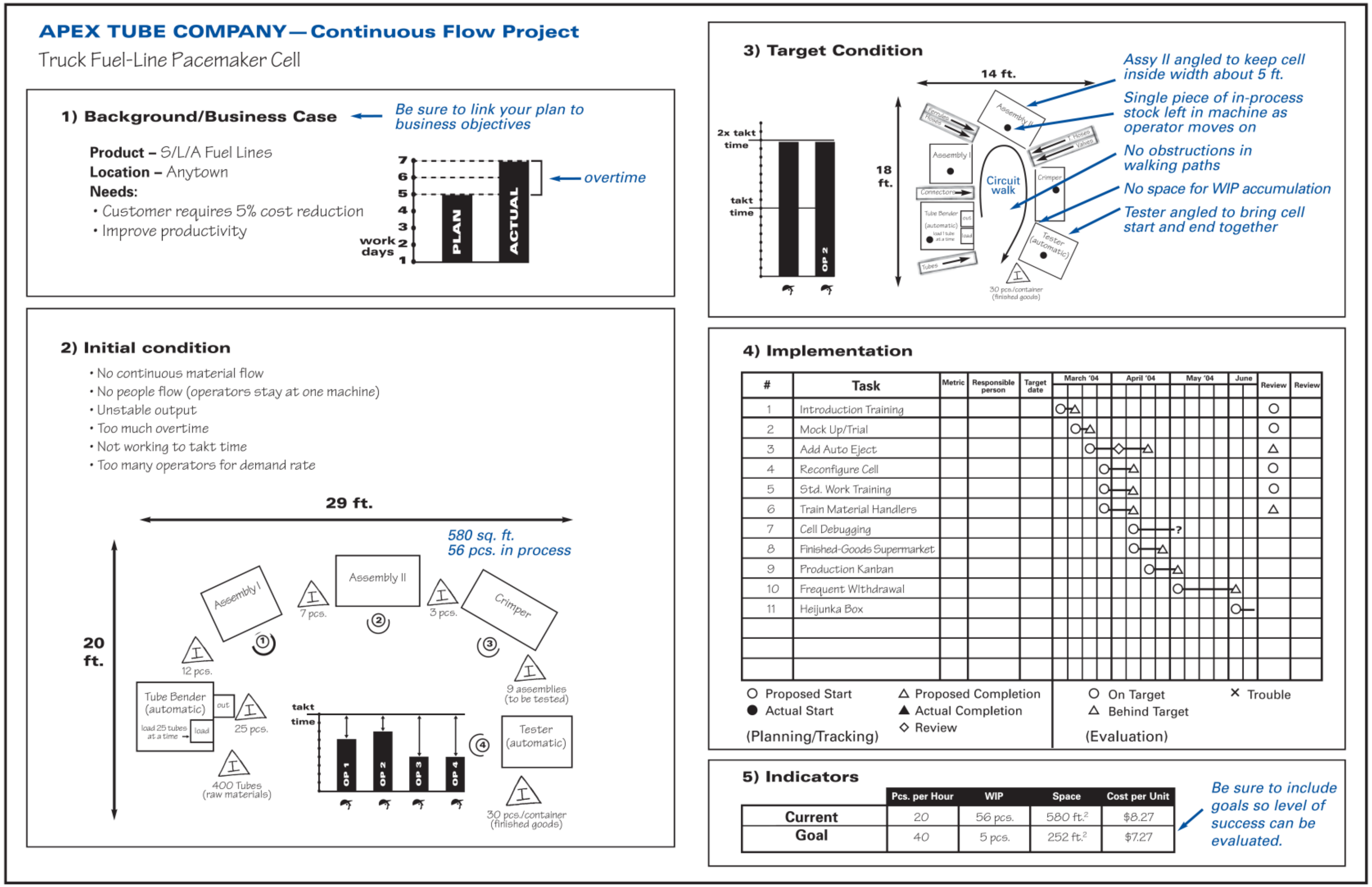


Figure 8.17: A3 Report Example [159]

8.8.5 Suggestion Systems

8.8.5.1 Definition

Today's workers are better educated and more literate that ever before. Moreover, today's companies need flexibility and creativity to sail rapidly changing markets, technology, and financial conditions. To continually improve, we need to engage all our team embers, especially those on the front lines, where the real work gets done [152].

Effective suggestion programs directly channel team member ideas to management and reward team member initiative.

8.8.5.2 Application

Health Risks:

Health risks are comprised of Low productivity of the workers (poor working conditions, low morale) and Bad weather or climate conditions. Suggestion systems can be a vital factor in improving employees' morale by engaging them in identifying work challenges and participating in solving them.

8.8.5.3 Guidelines

Successful suggestion programs share the following characteristics:

- Hassle-free process

Suggestion program rules should be clear and simple, as should standards for turnaround time and rewards. An effective approach is to award benefit points per suggestion. Team members could cash out benefit points as they accrued. Suggestion forms should be one page long, covering, current condition, suggested changes and key data.

- Quick decision-making

A firm standard should be applied to feedback, such as responding to all suggestions within one week. A clear process and standards support quick turnaround.

The evaluator's role is also critical. Evaluators assess suggestions and recommend recognition levels. There should be enough evaluators in each department to meet the turnaround standards.

- Fairness

All groups and departments should have fair access to suggestion programs and their benefits.

- Promotion

Suggestion programs should be promoted through different channels, such as report boards, regular reporting and feedback to management, including key info about the suggestions such as number of implemented suggestions and participation percentage.

- Intrinsic and extrinsic rewards

Extrinsic motivators include cash and gifts and are the most common rewards of suggestion programs. But they may not be the most powerful motivators. The psychological literature indicates that intrinsic motivators such as recognition, development opportunities, self-actualization may be more important.

8.9 The Summary of the Chapter

This chapter presented a systematic approach to minimize risks occurrence and their impact on the construction projects in Iraq using Lean Management.

First, the **FMEA** method was used to analyse the risk categories in terms of Occurrence, Severity, and Detection.

To determine whether it is possible to detect risks in the initial stages of the project, a supplementary questionnaire was developed for experts. shown in Appendix (**F**). Then Risk Priority Number (**RPN**) was assigned to each of the risk categories.

The Pareto Chart was used to quantify the contribution of each risk category to the total identified risks. The chapter suggested tackling risks contributing to at least 80 % of riks . These risks included Construction Mismanagement Risks, Legal Risks, Financial Risks, Risks of Design, Human Resources Risks, Technical Risks, Safety Risks, and Communication Risks.

Afterward, the Lean Six Sigma toolbox was investigated to identify the most relevant tools to overcome the selected list of risks. The identified tools included Lean Product Development and Design Management, Standard Work, PDCA, Visual Management, and suggestion schemes.

For each identified tool, a briefing is presented, including definitions, risk applications, and simplified implementation guidelines.

9. The Risk Management Model (RMM)

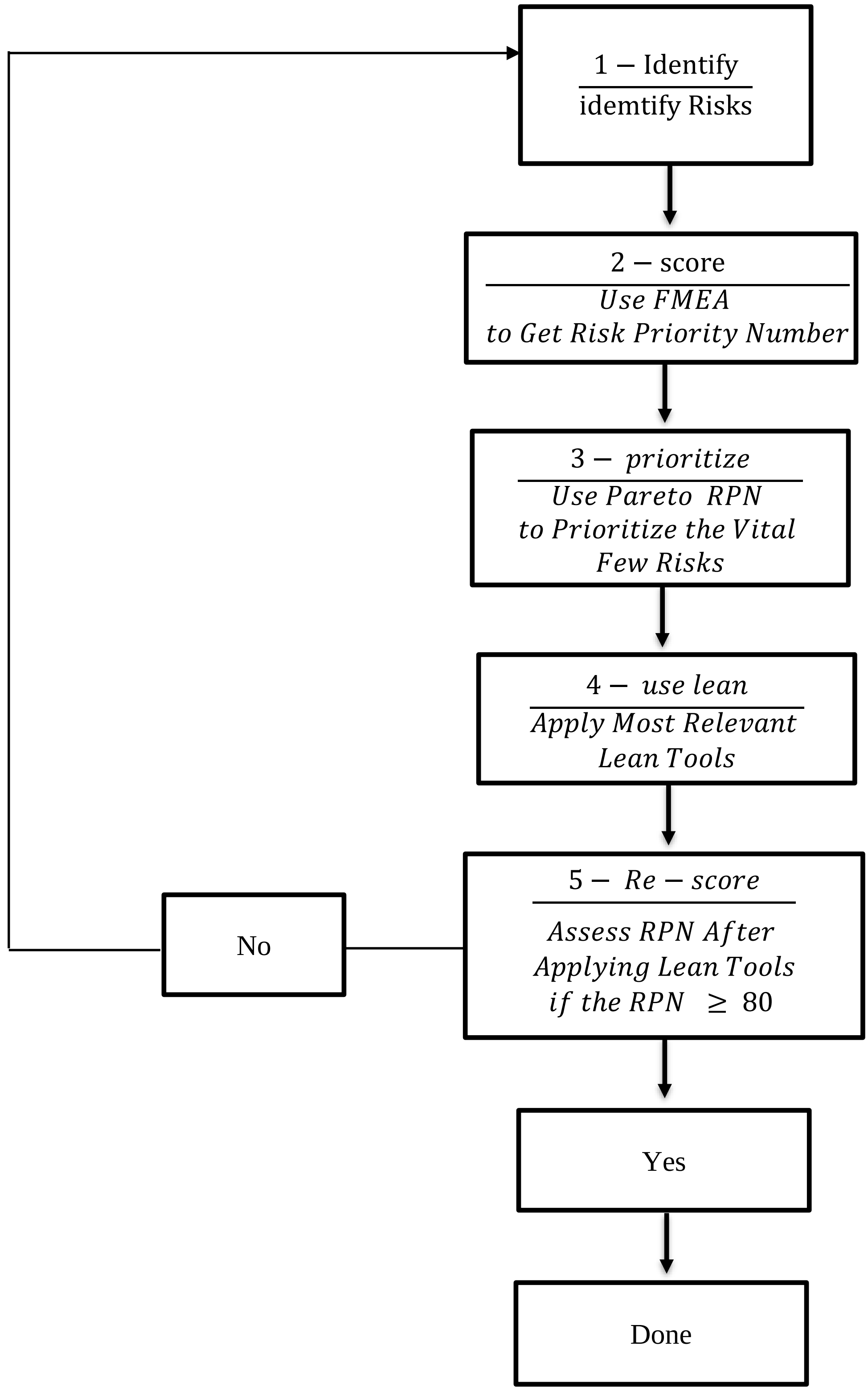


Figure 9.1: The Lean Management Framework for Risk Management/ RM Model (RMM) [source: own study]

9.1. Identify risks and analyze data

Through the use of a new method in this thesis, research in publications concerned with identifying risks, as well as evaluating experts and those involved in risk management for Iraq projects, the most important 36 risks were identified that significantly affect the workflow and implementation of the project paragraphs, and most of the risks were within a high-risk classification the severity of the risk was assessed using a Likert scale. The comprehensive questionnaire for all risk factors found, through the response of the target audience, the real importance of these factors. The reliability of the questionnaire is measured by Cronbach's Alpha and is equal to 0.973 for the entire questionnaire, which indicates excellent reliability of the questionnaire. The analysis of data in chapter 7 clarifies the correlation ratio between the risk categories varied from weak and moderate effect on each other by using the Spearman ring coefficient.

From the testing of the hypotheses (first and second) the t-test proves that the risks have an effect on the cost and time factors.

According to the ranging in the tables below, the researcher emphasizes the severity of the risks categories from the lowest grade to the high, in cost and time factors, it's clear that the communication risk factors are the highest danger and the human recourses risks are the lowest affected directly in the Iraqi projects in cost and time elements. This range is a simple way and parallels with the Pareto rating to help or illustrate the severity zone to the managers, the Pareto Analysis depends on the FMEA method so, it is more accurate to follow in ringing the risks.

The Questionnaire

The additional form created to get the answer to the main question focused on the ability of the respondents (12 experts) to detect risks; the answers were analysed by Pareto the most critical threats ranged according to their discovery rate (see Appendix **F**).

Table 9.1 illustrate the questionnaire level of identified risk category on Iraqi project costs [source: own study]

No	factor	Category of risk factors	Alpha	Level severity
9	cost	Human recourses risks	0.764	High
7	cost	Technical risks	0.766	High
5	cost	Market risks	0.766	High
11	cost	Safety risks	0.768	High
10	cost	Risks in mismanagement quality	0.769	High
4	cost	Legal risks	0.771	High
12	cost	Health risks	0.772	High
6	cost	Policy and politics	0.774	High
8	cost	Design risks	0.776	High
2	cost	Communications risks	0.778	High
3	cost	Financial risks	0.780	High
1	cost	Construction management risks	0.786	High

Table 9.2 illustrate the questionnaire level of identified risk category on Iraqi project time [source: own study]

No	factor	Category of risk factors	Alpha	Level severity
9	Time	Human recourses risks	0.794	High
10	Time	Risks in mismanagement quality	0.797	High
7	Time	Technical risks	0.799	High
8	Time	Design risks	0.801	High
4	Time	Legal risks	0.803	High
5	Time	Market risks	0.803	High
2	Time	Communications risks	0.804	High
12	Time	Health risks	0.805	High
6	Time	Policy and politics	0.805	High
11	Time	Safety risks	0.805	High
3	Time	Financial risks	0.810	High
1	Time	Construction management risks	0.815	High

The Lean Approach to Risk Management in Construction

Through the systematic identification and prioritization of risks, the study was able to identify the most critical risks relevant to the Iraqi Construction Industry. Moreover, the study shortlisted the Lean tools for the most pertinent four for those critical risks; the LPS, Standardized Work, Visual Management, and PDCA.

However, the identified risks cannot be considered a comprehensive list of current and future threats. This is due to the fact that one must watch out for the internal and external environment for potential other risks that can arise. Moreover, each risk score is subject to change according to each risk's Frequency, Impact, and Detectability. Therefore, the study introduces a systematic framework to be applied continuously to accommodate the potential arising and declining risks.

Identify

Through the current study, the risk definition process went through many stages that were previously explained in the first chapters, and it can be considered a reference for defining risks for any new project in Iraq, and any updates that the project manager and risk specialists see in the project are added to it.

This process is considered periodic and continuous during the duration of the project, and any new risks are added to the risk register, which is essential in recording any new risk or updating any old risk case that was previously recorded.

9.2 Score

The second step is to identify the Risk Priority Number for each of the Potential Risks. This is done using the FMEA method, which includes three components to identify for each risk:

Severity: the impact of each risk, with a score from 1 to 10.

Occurrence: The Frequency of each risk, with a score from 1 to 10

Detection: the probability of detecting the risk, with a score from 1 to 10.

Afterward, the Risk Priority Number is calculated using the following Formula;

$$\boldsymbol{Risk\ Priority\ Number\ (RPN) = Severity\ \times Occurance\ \times Detection}$$

9.3 Prioritize

Pareto tool can be used to identify the vital few risks to focus on. The target risk percent is specified first, and then the corresponding vital view risks are derived from the Pareto chart.

Percent is calculated using the following Formula

$$Percent_i = \frac{RPN_i}{\sum_{12}^{i=1} RPN_i}$$

And the cumulative percent is calculated using the following formula

$$Cum = \sum_{12}^{i=1} Percent_i$$

This study identified the risks that constitute 80 % of all risks. The remaining risks must be monitored as a watch-list for the potential increase or decrease of their RPN.

9.4 Use Lean

Although the study identified five essential tools that are suitable for the current high-priority risks, project stakeholders must be aware that the list can change according to the changing priorities of risks.

The 40 lean construction tools briefing is provided to assist project stakeholders in selecting the lean tool(s) to use.

The following are some recommended Lean tools to refer to for the uncovered risks; Risks in the mismanagement of quality, Policy and Politics Risks, and Market Risks. **Jidoka/Autonomation**, has been defined by Toyota as “automation with a human mind” and implies intelligent workers and machines identifying errors and taking quick countermeasures. Jidoka essentially means, “Build in quality at the source,” and comprises three things:

- Don’t accept defects.
- Don’t make them,
- Don’t pass them on.

It means making defect-free processes by continually strengthening process's ability to produce consistent, defect-free output. Also, it includes containment so that defects are quickly identified and contained in the zone.

Feedback has to be in place so that quick countermeasures can be taken. Jidoka applies to **risks in the management of quality** (R10), as it can eliminate reworks and poor quality.

LPS: as already briefed in chapter 8, the Last Planner System minimizes miscommunication and improves coordination between stakeholders and it improves shared understanding between teams. This helps with minimizing **policy and politics risks (R6)** by eliminating bureaucracy and streamlining communication among stakeholders [126].

Value Stream Mapping: Value stream mapping (VSM) is an invaluable tool that helps us grasp our current condition and identify improvement opportunities. Where there is a process, there are value-added steps, and there is waste. Thus, value stream mapping can also help us improve all our business processes. Value stream mapping can help with minimizing delay impact resulting from **Market Risks** (R5), by analysing process flow to reduce delivery variability and lead time.

In several situations, a project manager or team might not find a best practice solution to adopt from the lean toolbox, especially when there is no clear causal relationship between the challenge and the contributing factors. In such cases, the project team has to use their problem-solving skills to resolve such challenges. Plan-Do-Check-Act (PDCA) is covered in chapter 8 to assist with building problem-solving skills.

9.5 Re-Score

As already mentioned, the given score to each risk might increase or decrease, or even be replaced by a new risk. Therefore, the risk management effort is not a one-time job, and risks must be identified and assessed continuously to have a timely response.

The Implications for Practitioners

Whether a new project or an existing one, a project stakeholder or manager will be able, using the framework provided by this study to:

- Identify all potential risks related to the project(s) being managed.
- Assess Risk Occurrence, Severity, or Detection.
- Use FMEA to get a quantifiable Risk Priority (RPN) value.
- Prioritize risks using Pareto principles to focus the risk mitigation efforts on the vital few threats rather than the trivial mini.
- Use the catalogue of the lean 40 tools to select the essential tools relevant to the high-priority risks.

Benefit from the detailed guidelines provided for the fifth tools that were identified as most relevant to current construction projects in Iraq.

Continuously monitor the internal and external environment for current and potential risks.

The Limitations

The study was conducted in particular research scope where the findings are governed by the experiences from the surveyed professionals and therefore, the generalizability of the outcomes might be limited to respondents and the current risks situation in Iraq.

Despite the track record of Lean implementation within the construction industry (121), actual implementation of the framework to a specific category of construction projects in Iraq, whether infrastructure or superstructure projects, and to quantify the impact would solidify the contribution of this study.

Through the current study, the use of Lean tools reduced risks by a high percentage, reaching 80 percent, covering groups of previously identified risks, leaving only groups that constitute less risk according to Pareto analysis. It is possible to benefit from repetition by applying the model designed in this study with the same conditions to study other risks that are discovered and recorded in the risk register before starting the project, and the same procedures designed in the model are applied to obtain a risk reduction rate identical to this study. This model has aspects that can be modified according to the type of risks discovered as well as the circumstances and environment of the project, therefore becomes possible to use this new model on a broader and universal and not limited to Iraqi projects if the recommendations research are taken into consideration.

10 The Summary

10.1 The Research

The main objective of this study is to identify the most important risks that directly affect the progress of the construction Iraqi project. Through studying the reality of the Iraqi construction project, **50** types of risks were identified.

Defining risks was the basic step with which the researcher began the study, as the researcher relied on expanding the scope of the research on the most important risks that could directly or indirectly negatively affect the implementation of the construction project activities and their direct impact on cost and time.

To expand the scope of the research, the researcher studied the environment similar to construction projects in some Asian countries such as India, China, and others, and countries in the Middle East such as the Kingdom of Saudi Arabia, Egypt, and others.

The similar geographical, demographic, social, political, laws, and other environments that necessarily resemble the State of Iraq and the implementation of construction works, and this in turn provides the possibility of discovering risks that may be undiscovered in Iraq and the possibility of occurring in Iraqi projects in the future.

After searching Asian sources, which amounted to 30 recent studies for last 5-6 years, the researcher identified a total of **34** risks that were repeated in high proportions in published practical researches.

The second research stage, in which the researcher continued to discover risks, was researching published practical research that was issued to researchers from Iraq last 5-6 years, the researcher identified the risks that affect the construction project, where risks were stated in a concept similar to the nomenclature adopted by Asian research, and where a new risk was added to be the total number of risks that were approved was **35** risks and they were classified into seven risk groups.

The researcher adopted field research like brainstorming, experts interview that added a new risk identified, so the final number become **36** risks studied through the questionnaire.

The researcher conducted the survey using the questionnaire, which was conducted in two stages.

The first experimental stage included 50 respondents to obtain the stability of the sample and evaluate the questionnaire, The validity of the questionnaire is made by distributing a 50 samples questionnaire as a test for the reliability connected by computing Cronbach's Alpha which equals 0.973 for the entire questionnaire, which indicates excellent reliability of the whole questionnaire. The target sample which was specified at 385 respondents. To survey the largest engineering segment and stakeholders, the second stage of the questionnaire (The main) was prepared and distributed to 600 respondents.

The researcher obtained 512 responses, which is almost double the required number. This evidence emphasizes the importance of the topic and the interest of the respondent in the subject of the questionnaire since the risks are in direct contact with their work.

To obtain greater accuracy when answering the questionnaire, the researcher distributed the risks into 12 groups instead of 7 groups. The graphs resulting from the respondents' answers to all four questionnaire questions for each risk category showed that the risks are rated very high with very high percentages.

The researcher conducted the required statistical operations for answers and analysed them, the arithmetic mean, standard deviation, Cronbach Alpha.

The stability level of Cronbach Alpha was found at a high level for each risk category regarding the impact of these risks on the cost and time factors. The level of stability ranges according to cost factor between 0.815 in the category mismanagement risk factors and the lowest is 0.794 in Human resources risk factors, while the level of stability ranges in time factor between 0.780 in the category financial risk factors and the lowest is 0.764 in Human Resources Risk factors.

The researcher found the risk factors correlation by using the Spearman correlation and it's within the weak and moderate range. In order to examine the research hypotheses, the researcher calculated the T-test, where both hypothesis H1 are accepted.

To develop risk management in Iraqi construction projects, the researcher studied the possibility of adding Lean tools and the Lean Six Sigma Principles. Where the researcher selected the FMEA method which is one of the 40 tools of the lean-to-prioritize risks by calculating the RPN percentage for each category.

To obtain the RPN score, one can simply multiply three RPN elements that are typically ranked on a scale of ten, namely the severity of the failure effect (S), probability of failure-mode Occurrence (O), and probability of the failure being detected (D); that is, RPN = S × O × D. The severity and occurrence are calculated according to the questionnaire results data while the detection value is calculated by a supplementary questionnaire was developed for experts (12 experts see Appendix F).

Depending on the RPN values Pareto Analysis to Identify Risk Categories Ranking & Contribution was conducted. The highest risk RPN score is for Construction Mismanagement Risks, contributing 11.8% to total Risks, and lowest were the Market Risks 6.0 %.

Based on the Pareto's principle, the first nine risk groups from the Pareto classification were selected, which constitute 80% of the total risks expected to occur in the project, therefore, the target risk categories and their subsequent factors would be R1, R4, R3, R8, R9, R7, R11, R2 and R12, respectively.

In this study, 9 groups of risks were considered based on the Pareto principle, and five lean tools were selected and identified in detail that deal with these nine groups to reduce their higher risk percentages 79.6%, achieved by applying the five tools each time during repetition, comparing the results, and so on. This will be an organized work method. To manage risks, risks discovered in the future can be added according to the type and size of the project, as well as new tools from the list of lean management tools 40, this part will be the main core of the RMM model which is one of the outputs of the study to manage risk reduce prosses. Through this model, limits can be changed according to the budget and schedule specific to the project, which gives the project manager resilience to control the tools quickly and directly.

Finally, when adopting the research and treatment method used in this study, taking into account the conditions for using the proposed risk management model (RMM), it can thus be adopted as a comprehensive universal model that is not limited to Asia and Iraq in particular, which provides benefit to all construction projects managers around the world.

10.2 Lessons Learnt

- Through interviews with specialists, the researcher found that a large percentage of project management does not update the risk register during the course of the project, as this is considered very important in assessing future risks and developing solutions.
- Lean management has a broad range of tools and concepts that can be adopted to improve construction projects management in general, as well as improving risk management.
- Using all known tools would not serve the purpose of managing risks, until the priority risks are identified. Once the important threats are recognized, the project manager and stakeholder can refer to the lean toolbox, according to the potential benefit and scope of each tool.
- Combining FMEA with Pareto Principle helps in identifying the risk priorities in terms of severity, detection and occurrence.
- Risk detection is an important element in risk assessment, as risk priority can change according to the probability of detectability of such risk. A severe, frequent risk that can be detected on the spot and dealt with, will have a lower RPN than a severe, frequent risk that will be detected too late, if at all.
- PDCA methodology helps with the challenging situations, where best practices or tools are yet to be identified.
- Risk management is a cyclical, continuous endeavour and should not be fixed once countermeasures for the current risks are identified.

10.3 Future Research

- Despite the developed Lean Framework for Risk Management, the study suggests applying it to a specific category of construction project. This future research should start with the framework and apply it to specific project(s) and it should end by quantifying if the same risks experienced reduction in severity, occurrence or improved detection. Hence, a comparison between the RPN before and after application would be evident of the practicality of the proposed framework and its usefulness to construction projects' stakeholders.
- The scope of this study covered only the risks that contribute to 80% of the total risk. Some key tools were introduced as a guidance for the uncovered risks. Future research that covers the remaining risk categories, R10, R6 and R5 is recommended.

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Appendixes

Appendix A

The appendix is an excel sheet that shows the list of research, publications, and specialized sites in Asia, which were collected by the researcher in this study and interested in the issue of construction risk management in Asia, including lists of the most important risks that were recorded by the researchers.

Appendix B

The appendix is an excel sheet that shows the list of research, publications, and specialized sites in Iraq, which were collected by the researcher in this study and interested in the issue of construction risk management in Iraq, including lists of the most important risks that were recorded by the researchers.

Appendix C

List of Arbitrators in the Pilot Study

No.	Name	Position and Organization
1.	Eng. Ali Amer Abudallah	Consultant. MSc, Civil engineering in Iraqi Ministry of Electricity, Project Manager
2.	Dr. Maher Murad Jebuer	Lecturer, civil engineering faculty, University of Baghdad
3.	Dr. Mohammed Erdini	Consultant. PhD, civil engineering in Shraa Emmar construction company, Baghdad
4.	Dr. Bassman Riyad	Assistant Professor civil engineering faculty, University of Technology, Baghdad
5.	Dr. Wissam H. al-Sudani	Head of Dept, Al-Idrisi Engineering Consulting Centre, Baghdad-Iraq
6.	Prof. Mahdi karkush	Professor, civil engineering faculty, University of Baghdad-Iraq
7.	Eng. Mahmood abadi Al-khazali	Consultant. Civil engineering, Project Manager, Municipality of Baghdad, Head Quarter
8.	Eng Mustafa Al-Sadi	Consultant. Civil engineering, Project Manager, Municipality of Baghdad, Al -Rasheed Sector
9.	Eng. Mahmood Al-Azawi	Consultant. MSc, Civil Engineering in Iraqi Ministry of Electricity, Project Manager -Distribution Electric Department
10.	Eng. Ali Al-Rawi	Contractor and Civil Engineering in Awtad Baghdad Contracting Office, Baghdad- Iraq
11	Dr. Zaid Mohammed Kani	Assistant Professor civil engineering faculty, University of Anbar, Anbar-Iraq
12	Arch. Hassan Mansour	Consultant. Architecture in Al-Mansour office for consultancy and contracting, Baghdad-Iraq

Appendix D

The appendix is the main questionnaire form that was distributed to the participants.

https://docs.google.com/forms/d/18itDTTHQCmCIzEGPyNYx_CvwmHSIWDHGv5uziMO8x0/edit#responses

https://docs.google.com/spreadsheets/d/1hxbGGyoElI5PWZ8M6sx3lV1c9yBThheQPHLjm6fwqM4/edit?resourcekey#gid=1712906196

استبيان خاص بتقييم اهم المخاطر في مشاريع العراق الانشائية A questionnaire for assessing the most important risks in Iraq's construction projects

المتغيرات الديموغرافية

*مطلوب

1. الجنس*

حدد دائرة واحدة فقط.

- ذكر Male
- انثى female

التخطي إلى السؤال 2

ملاحظة : يمكنك اختيار اكثرمن اختيار للاسئلة الثلاث التالية وذلك يعتمدعلى مجال وسنوات خبرتك مثال (عملت كمهندس في القطاع الخاص لمدة 1-5 سنوات ثم بعد ذلك عملت كمقاول لمدة 6-10 سنوات)Note: You can choose more than one choice for the following three questions, depending on your field and years of experience, for example (Worked as an engineer in the private sector for 1-5 years and then worked as a contractor for 6-10 years)

2. سنوات الخبرة في مجال الانشاءات / صناعة البناء Experience in construction industry *

حدد كل الإجابات الملائمة.

- 1-5 years
- 6-10 years
- 11-15years
- 16- 20years
- 21- and above

3. مجال العمل Category*

حدد كل الإجابات الملائمة.

- Public ☐
- Private ☐

4. الوظيفة في المشروع Party*

حدد كل الإجابات الملائمة.

- مستثمر Investor ☐
- مقاول Contractor ☐
- مهندس (استشاري , موقع , مشرف ,الخ) Engineer (consultant ,site ,supervisor ,etc.) ☐
- مصمم Designer ☐
- مقاول ثانوي Subcontractor ☐

5. الموقع الوظيفي (الدور) The Role*

حدد دائرة واحدة فقط.

- في الادارة العليا للمشروع / المشروعات Top Management ◯
- في الادارة الوسطى Middle Management ◯
- مختص Specialist ◯

6. التحصيل الدراسي Academic*

حدد دائرة واحدة فقط.

- PhD ◯
- Master's ◯
- Bachelor's ◯

7. اين عملت بالمشاريع الانشائية ؟ ? *
Where did you work on construction projects

حدد دائرة واحدة فقط.

- مشاريع محلية Domestic
- مشاريع خارج العراق International
- مشاريع خارج وداخل العراق Domestic & International

8. هل عملت مع شركات عالمية لديها مشاريع انشائية داخل العراق وتعمل بمنهاج ادارة المخاطر ؟ *
Have you worked with international companies that have construction projects inside Iraq that work with the risk management curriculum? (risk management plan)

حدد دائرة واحدة فقط.

- Yes
- No

فئات المخاطر
Risk categories

ادناه 12 فئة خطر ، تضم كل فئة تحتوي على عوامل الخطر التي تهدد العمل الانشائي بنسبة ما من ناحية الوقت والكلفة Below are 12 risk categories, each category contains risk factors that threaten construction work in a proportion in terms of time and cost

اولا : مخاطر تتعلق بسوء إدارة المشروع (إدارية) Construction mismanagement Risks

1- الضعف او سوء التخطيط والإدارة
Lack of planning and management
2- الضعف اوعدم وضوح النطاق أو تغييرات في نطاق المشاريع وتكلفته
Lack of scope clarity or changes to the projects' scope and cost
3- ادارة سيئة للمشروع
Poor management
4- عدم كفاية تخطيط وإدارة الموقع
Inadequate Site planning and management
5- التأخر في اتخاذ القرارات الخاصة بالمشروع
Delay in making decisions

9. 1.What is the impact of the above factors on cost overruns of the construction projects? ما هو تأثير العوامل المذكورة أعلاه على تجاوز الكلفة في مشاريع البناء؟ *

حدد دائرة واحدة فقط.

- A. Very strong
- B. Quite strong
- C. Moderate
- D. Rather low
- E. Very low

10. 2. What is the impact of the above factors on the delay in completing the construction projects?ما هو تأثير العوامل المذكورة أعلاه على تأخير إنجاز المشاريع الإنشائية؟(عامل الوقت) *

حدد دائرة واحدة فقط.

- A. Very strong
- B. Quite strong
- C. Moderate
- D. Rather low
- E. Very low

11. 3. ?How often does it appear تظهر بدرجة ؟*

حدد دائرة واحدة فقط.

- A. Very high
- B. High
- C. Medium
- D. Few
- E. Very few

12. 4. What is the impact of these factors on the occurrence of other risks? (remaining risk groups) ما مدى تاثير هذة العوامل على حدوث اخطار اخرى؟ (مجموعات الخطر الباقية) *

حدد دائرة واحدة فقط.

- A. Very high
- B. High
- C. Medium
- D. Few
- E. Very few

ثانيا: مخاطر التواصل Communication Risks

1. ضعف التواصل مع العميل(صاحب العمل) مع توقعات غير دقيقة Poor communication with client/Imprecise expectation

2.ضعف التواصل بين اطراف المشروع Poor communication between the parties

13. 1.What is the impact of the above factors on cost overruns of the construction projects? ما هو تأثير العوامل المذكورة أعلاه على تجاوز الكلفة في مشاريع البناء؟

حدد دائرة واحدة فقط.

- A. Very Strong
- B. Quite strong
- C. Moderate
- D. Rather low
- E. Very low

14. 2. What is the impact of the above factors on the delay in completing the construction projects?ما هو تأثير العوامل المذكورة أعلاه على تأخير إنجاز المشاريع الإنشائية؟(عامل الوقت)

حدد دائرة واحدة فقط.

A. Very strong

B. Quite strong

C. Moderate

D. Rather low

E. Very low

15. 3. ?How often does it appear تظهر بدرجة ؟*

حدد دائرة واحدة فقط.

A. Very high

B. High

C. medium

D. Few

E. Very few

16. 4. What is the impact of these factors on the occurrence of other risks? (remaining risk groups) ما مدى تاثير هذة العوامل على حدوث اخطار اخرى؟ (مجموعات الخطر الباقية) *

حدد دائرة واحدة فقط.

A. Very high

B. High

C. medium

D. Few

E. Very few

ثالثا : مخاطر مالية Financial risks

1- مشاكل مالية عند صاحب العمل Financial problems of the client

2- المشاكل المالية عند المقاول Financial problems of the contractor

3- تأخير أو رفض المدفوعات للمقاولين أو المقاولين من الباطن أو العمال Delaying or refusing payments to contractors, subcontractors or workers

4- عوامل اقتصادية خارجية مثل (تقلبات الأسعار وأسعار الفائدة، التضخم، الركود) External economic factors (fluctuations of prices and interest rates, inflation, recession)

17. 1.What is the impact of the above factors on cost overruns of the construction projects? ما هو تأثير العوامل المذكورة أعلاه على تجاوز الكلفة في مشاريع البناء؟ *

حدد دائرة واحدة فقط.

- A. Very strong
- B.Quite strong
- C. Modreate
- D. Rather low
- E. Very low

18. 2. What is the impact of the above factors on the delay in completing the construction projects? ما هو تأثير العوامل المذكورة أعلاه على تأخير إنجاز المشاريع الإنشائية؟ (عامل الوقت) *

حدد دائرة واحدة فقط.

- A. Very strong
- B. Quite strong
- C. Moderate
- D. Rather low
- E. Very low

19. 3. ?How often does it appear تظهر بدرجة ؟*

حدد دائرة واحدة فقط.

A. Very high
B. High
C. Medium
D. Few
E. Very few

20. 4. What is the impact of these factors on the occurrence of other risks? (remaining risk groups) ما مدى تاثير هذة العوامل على حدوث اخطار اخرى؟ (مجموعات الخطر الباقية) *

حدد دائرة واحدة فقط.

A. Very high
B. High
C. Medium
D. Few
E. Very few

رابعا : مخاطر قانونية Legal risks
1. الضعف التعاقدي (ضعف في بنود العقد) Contractual Weakness
2. التناقضات والأخطاء في وثائق العقد Inconsistencies and mistakes in contract documents
3. الإرهاب والتخريب Terrorism and Sabotage
4.التغييرات في القانون المعمول به اثناء تنفيذ المشروع Changes in the applicable laلضعف التعاقدي (ضعف في بنود العقد) Contractual Weakness
2. التناقضات والأخطاء في وثائق العقد Inconsistencies and mistakes in contract documents
3. الإرهاب والتخريب Terrorism and Sabotage
4.التغييرات في القانون المعمول به اثناء تنفيذ المشروع **Changes in the applicable law**

21. 1.What is the impact of the above factors on cost overruns of the construction projects? ما هو تأثير العوامل المذكورة أعلاه على تجاوز الكلفة في مشاريع البناء؟ *

حدد دائرة واحدة فقط.

- A. Very strong
- B. Quite strong
- C. Moderate
- D. Rather low
- E. Very low

22. 2. What is the impact of the above factors on the delay in completing the construction projects?ما هو تأثير العوامل المذكورة أعلاه على تأخير إنجاز المشاريع الإنشائية؟(عامل الوقت) *

حدد دائرة واحدة فقط.

- A. Very strong
- B. Quite strong
- C. Moderate
- D. Rather low
- E. Very low

23. 3. ?How often does it appear تظهر بدرجة ؟*

حدد دائرة واحدة فقط.

- A. Very high
- B. High
- C. Medium
- D. Few
- E. Very few

24. 4. What is the impact of these factors on the occurrence of other risks? (remaining risk groups) ما مدى تاثير هذة العوامل على حدوث اخطار اخرى؟ (مجموعات الخطر الباقية) *

حدد دائرة واحدة فقط.

A. Very high
B. High
C. Medium
D. Few
E. Very few

خامسا : مخاطر تتعلق بالسوق Market risks
1. ضعف أداء النقل واللوجستيك Transportation and logistic
2. طريقة إرساء العطاء على الشركات او المقاولين الأقل سعرا Lowest bidding procurement method
3. التأخير في تسليم المواد Delays in the delivery of materials

25. 1.What is the impact of the above factors on cost overruns of the construction projects? ما هو تأثير العوامل المذكورة أعلاه على تجاوز الكلفة في مشاريع البناء؟ *

حدد دائرة واحدة فقط.

A. Very strong
B. Quite strong
C. Moderate
D. Rather low
E. Very low

26. 2. What is the impact of the above factors on the delay in completing the construction projects?ما هو تأثير العوامل المذكورة أعلاه على تأخير إنجاز المشاريع الإنشائية؟(عامل الوقت) *

حدد دائرة واحدة فقط.

- A. Very strong
- B. Quite strong
- C. Moderate
- D. Rather low
- E. Very low

27. 3. ?How often does it appear تظهر بدرجة ؟ *

حدد دائرة واحدة فقط.

- A. Very high
- B. High
- C. Medium
- D. Few
- E. Very few

28. 4. What is the impact of these factors on the occurrence of other risks? (remaining risk groups) ما مدى تاثير هذة العوامل على حدوث اخطار اخرى؟ (مجموعات الخطر الباقية) *

حدد دائرة واحدة فقط.

- A. Very high
- B. High
- C. Medium
- D. Few
- E. Very few

سادسا : مخاطر سياسية Policy and Politics Risks
1- البيروقراطية المفرطة Excessive bureaucracy
2- التأخير بسبب الوضع السياسي المعقد Delays due to complex political situation

29. 1.What is the impact of the above factors on cost overruns of the construction projects? ما هو تأثير العوامل المذكورة أعلاه على تجاوز الكلفة في مشاريع البناء؟ *

حدد دائرة واحدة فقط.

- A. Very strong
- B. Quite strong
- C. Moderate
- D. Rather low
- E. Very low

30. 2. What is the impact of the above factors on the delay in completing the construction projects?ما هو تأثير العوامل المذكورة أعلاه على تأخير إنجاز المشاريع الإنشائية؟(عامل الوقت) *

حدد دائرة واحدة فقط.

- A. Very strong
- B. Quite strong
- C. Moderate
- D. Rather low
- E. Very low

31. 3. ?How often does it appear تظهر بدرجة ؟*

حدد دائرة واحدة فقط.

A. Very high
B. High
C. Medium
D. Few
E. Very few

32. 4. What is the impact of these factors on the occurrence of other risks? (remaining risk groups) ما مدى تاثير هذة العوامل على حدوث اخطار اخرى؟ (مجموعات الخطر الباقية) *

حدد دائرة واحدة فقط.

A. Very high
B. High
C. Medium
D. Few
E. Very few

سابعا : مخاطر فنية Technical Risks
1- أعمال التغيير / اوامر الغيار Variation Works/Change order
2- ظروف الأرض غير المتوقعة (عدم إجراء تحريات التربة في الموقع بصورة صحيحة او دقيقة) Unforeseen ground conditions (lack of site investigation)
3- وقت غير كاف (تم حساب الوقت للفقرات بصورة غير دقيقة) Time underestimation (inadequate time)

33. 1.What is the impact of the above factors on cost overruns of the construction projects? ما هو تأثير العوامل المذكورة أعلاه على تجاوز الكلفة في مشاريع البناء؟ *

حدد دائرة واحدة فقط.

- A. Very strong
- B. Quite strong
- C. Moderate
- D. Rather low
- E. Very low

34. 2. What is the impact of the above factors on the delay in completing the construction projects?ما هو تأثير العوامل المذكورة أعلاه على تأخير إنجاز المشاريع الإنشائية؟(عامل الوقت) *

حدد دائرة واحدة فقط.

- A. Very strong
- B. Quite strong
- C. Moderate
- D. Rather low
- E. Very low

35. 3. ?How often does it appear تظهر بدرجة ؟ *

حدد دائرة واحدة فقط.

- A. Very high
- B. High
- C. Medium
- D. Few
- E. Very few

36. 4. What is the impact of these factors on the occurrence of other risks? (remaining risk groups) ما مدى تاثير هذة العوامل على حدوث اخطار اخرى؟ (مجموعات الخطر الباقية) *

حدد دائرة واحدة فقط.

A. Very high
B. High
C. Medium
D. Few
E. Very few

ثامنا:مخاطر التصميم Design Risks
1-أخطاء في التصميم أو تغييرات في التصميم اثناء التنفيذ Errors in Design or changes

2-عيوب التصميم والرسم Design and drawing flaws

3-تصميم معماري غير ملائم لمتطلبات المشروع بنسبة ما Inadequate architecture design

37. 1.What is the impact of the above factors on cost overruns of the construction projects? ما هو تأثير العوامل المذكورة أعلاه على تجاوز الكلفة في مشاريع البناء؟ *

حدد دائرة واحدة فقط.

A. Very strong
B. Quite strong
C. Moderate
D. Rather low
E. Very low

38. 2. What is the impact of the above factors on the delay in completing the construction projects?ما هو تأثير العوامل المذكورة أعلاه على تأخير إنجاز المشاريع الإنشائية؟(عامل الوقت) *

حدد دائرة واحدة فقط.

- A. Very strong
- B. Quite strong
- C. Moderate
- D. Rather low
- E. Very low

39. 3. ?How often does it appear تظهر بدرجة ؟*

حدد دائرة واحدة فقط.

- A. Very high
- B. High
- C. Medium
- D. Few
- E. Very few

40. 4. What is the impact of these factors on the occurrence of other risks? (remaining risk groups) ما مدى تاثير هذة العوامل على حدوث اخطار اخرى؟ (مجموعات الخطر الباقية) *

حدد دائرة واحدة فقط.

- A. Very high
- B. High
- C. Medium
- D. Few
- E. Very few

تاسعا: مخاطر الموارد البشرية Human Resources Risks

1- عدم كفاية / نقص العمالة Insufficient number/lack of workers

2- العدد غير الكافي / نقص الكوادر المؤهلة Insufficient number/lack of qualified personnel

41. 1.What is the impact of the above factors on cost overruns of the construction projects? ما هو تأثير العوامل المذكورة أعلاه على تجاوز الكلفة في مشاريع البناء؟ *

حدد دائرة واحدة فقط.

- A. Very strong
- B. Quite strong
- C. Moderate
- D. Rather low
- E. Very low

42. 2. What is the impact of the above factors on the delay in completing the construction projects? ما هو تأثير العوامل المذكورة أعلاه على تأخير إنجاز المشاريع الإنشائية؟(عامل الوقت) *

حدد دائرة واحدة فقط.

- A. Very strong
- B. Quite strong
- C. Moderate
- D. Rather low
- E. Very low

43. 3. ?How often does it appear تظهر بدرجة ؟*

حدد دائرة واحدة فقط.

A. Very high
B. High
C. Medium
D. Few
E. Very few

44. 4. What is the impact of these factors on the occurrence of other risks? (remaining risk groups) ما مدى تاثير هذة العوامل على حدوث اخطار اخرى؟ (مجموعات الخطر الباقية) *

حدد دائرة واحدة فقط.

A. Very high
B. High
C. Medium
D. Few
E. Very few

عاشرا:مخاطر سوء ادارة الجودة Risks in mismanagement quality
1- إعادة العمل بسبب رداءة الجودة أو عيوب في التنفيذ Reworks due to poor quality or flaws in execution

2- نوعية رديئة أو تلف مواد البناء Poor quality or damage of building material

45. 1.What is the impact of the above factors on cost overruns of the construction projects? ما هو تأثير العوامل المذكورة أعلاه على تجاوز الكلفة في مشاريع البناء؟ *

حدد دائرة واحدة فقط.

A. Very strong
B. Quite strong
C. Moderate
D. Rather low
E. Very low

46. 2. What is the impact of the above factors on the delay in completing the construction projects?ما هو تأثير العوامل المذكورة أعلاه على تأخير إنجاز المشاريع الإنشائية؟(عامل الوقت) *

حدد دائرة واحدة فقط.

A. Very strong
B. Quite strong
C. Moderate
D. Rather low
E. Very low

47. 3. ?How often does it appear تظهر بدرجة ؟*

حدد دائرة واحدة فقط.

A. Very high
B. High
C. Medium
D. Few
E. Very few

48. 4. What is the impact of these factors on the occurrence of other risks? (remaining risk groups) ما مدى تاثير هذة العوامل على حدوث اخطار اخرى؟ (مجموعات الخطر الباقية) *

حدد دائرة واحدة فقط.

A. Very high
B. High
C. Medium
D. Few
E. Very few

احد عشر : مخاطر تتعلق بالسلامة Safety Risks
1- ضعف او عدم كفاية متطلبات السلامة في المشروع lack of Safety in construction

2- التأخير بسبب عدم الكفاءة أو قلة خبرة العمال Delays due to Incompetence, or lack of experience of workers

3- أحداث عشوائية (مثل الحوادث) Random events (e.g., accidents)

49. 1.What is the impact of the above factors on cost overruns of the construction projects? ما هو تأثير العوامل المذكورة أعلاه على تجاوز الكلفة في مشاريع البناء؟ *

حدد دائرة واحدة فقط.

A. Very strong
B. Quite strong
C. Moderate
D. Rather low
E. Very low

50. 2. What is the impact of the above factors on the delay in completing the construction projects?ما هو تأثير العوامل المذكورة أعلاه على تأخير إنجاز المشاريع الإنشائية؟(عامل الوقت) *

حدد دائرة واحدة فقط.

A. Very strong
B. Quite strong
C. Moderate
D. Rather low
E. Very low

51. 3. ?How often does it appear تظهر بدرجة ؟*

حدد دائرة واحدة فقط.

A. Very high
B. High
C. Medium
D. Few
E. Very few

52. 4. What is the impact of these factors on the occurrence of other risks? (remaining risk groups) ما مدى تاثير هذة العوامل على حدوث اخطار اخرى؟ (مجموعات الخطر الباقية) *

حدد دائرة واحدة فقط.

A. Very high
B. High
C. Medium
D. Few
E. Very few

اثنا عشر: مخاطر تتعلق بالصحة Health Risks

1- مرض أو وفاة العمال Illness or death of workers
2- انخفاض إنتاجية العمال (ظروف عمل سيئة، معنويات منخفضة) Low productivity of the workers (poor working conditions, low morale)
3- سوء الأحوال الجوية أو الظروف المناخية Bad weather or climate conditions

53. 1.What is the impact of the above factors on cost overruns of the construction projects? ما هو تأثير العوامل المذكورة أعلاه على تجاوز الكلفة في مشاريع البناء؟ *

حدد دائرة واحدة فقط.

- A. Very strong
- B. Quite strong
- C. Moderate
- D. Rather low
- E. Very low

54. 2. What is the impact of the above factors on the delay in completing the construction projects?ما هو تأثير العوامل المذكورة أعلاه على تأخير إنجاز المشاريع الإنشائية؟(عامل الوقت) *

حدد دائرة واحدة فقط.

- A. Very strong
- B. Quite strong
- C. Moderate
- D. Rather low
- E. Very low

55. 3.? How often does it appear تظهر بدرجة ؟ *

حدد دائرة واحدة فقط.

- A. Very high
- B. High
- C. Medium
- D. Few
- E. Very few

56. 4. What is the impact of these factors on the occurrence of other risks? (remaining risk groups) ما مدى تاثير هذة العوامل على حدوث اخطار اخرى؟ (مجموعات الخطر الباقية) *

حدد دائرة واحدة فقط.

- A. Very high
- B. High
- C. Medium
- D. Few
- E. Very few

Appendix E

The attachment is the statistical numbers of the total engineers and designers registered in the Iraqi engineering Association in Baghdad, until 2022.

7/17/22, 3:44 PM Vienna BI - تقرير احصائي (شعبة/فرع) مستحدث

تقرير احصائي (شعبة/فرع) مستحدث

اعداد المهندسين	الشعب							
الفروع	عامة.	كهرباء.	كيمياوي.	مدني.	معماري.	ميكانيك.	نفط.	Total
أربيل	11	502	47	779	93	333	27	1,792
الأنبار	75	2,411	256	2,519	63	1,677	129	7,130
البصرة	446	6,774	1,398	4,249	383	4,988	1,384	19,622
الديوانية	128	1,288	310	1,416	52	1,302	89	4,585
السليمانية	7	442	52	797	60	328	24	1,710
المثنى	66	704	244	889	75	547	59	2,584
النجف	157	3,449	198	2,653	119	2,192	129	8,897
بابل	594	3,163	512	3,364	247	3,617	181	11,678
بغداد	2,522	43,855	6,385	29,082	4,803	28,261	2,031	116,939
دهوك	4	158	12	231	19	168	3	595
ديالى	141	3,026	305	1,872	85	1,543	193	7,165
ذي قار	340	2,646	448	2,262	65	2,205	475	8,441
صلاح الدين	70	1,074	380	1,268	58	794	134	3,778
كربلاء	353	2,133	319	1,960	148	1,830	185	6,928
كركوك	435	2,876	358	2,453	181	1,614	928	8,845
ميسان	79	1,971	320	913	47	1,110	329	4,769
نينوى	835	6,107	122	4,979	795	3,065	193	16,096
واسط	121	1,461	146	1,435	74	1,472	128	4,837
	0	0	0	1	0	0	0	1
Total	6,384	84,040	11,812	63,122	7,367	57,046	6,621	236,392

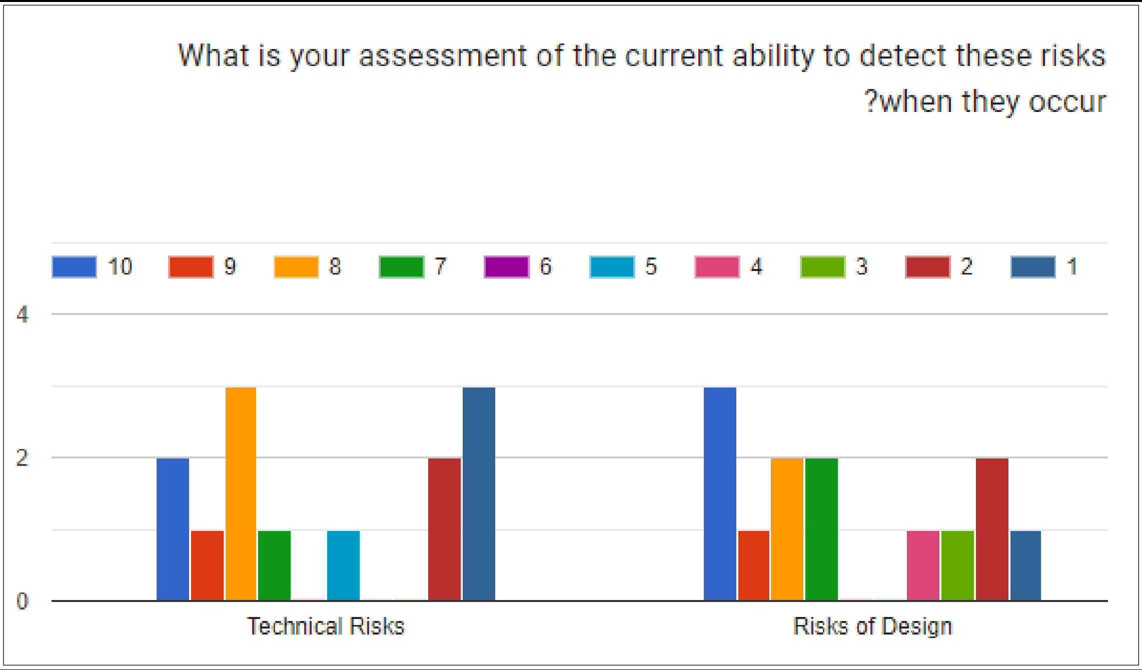
Filters

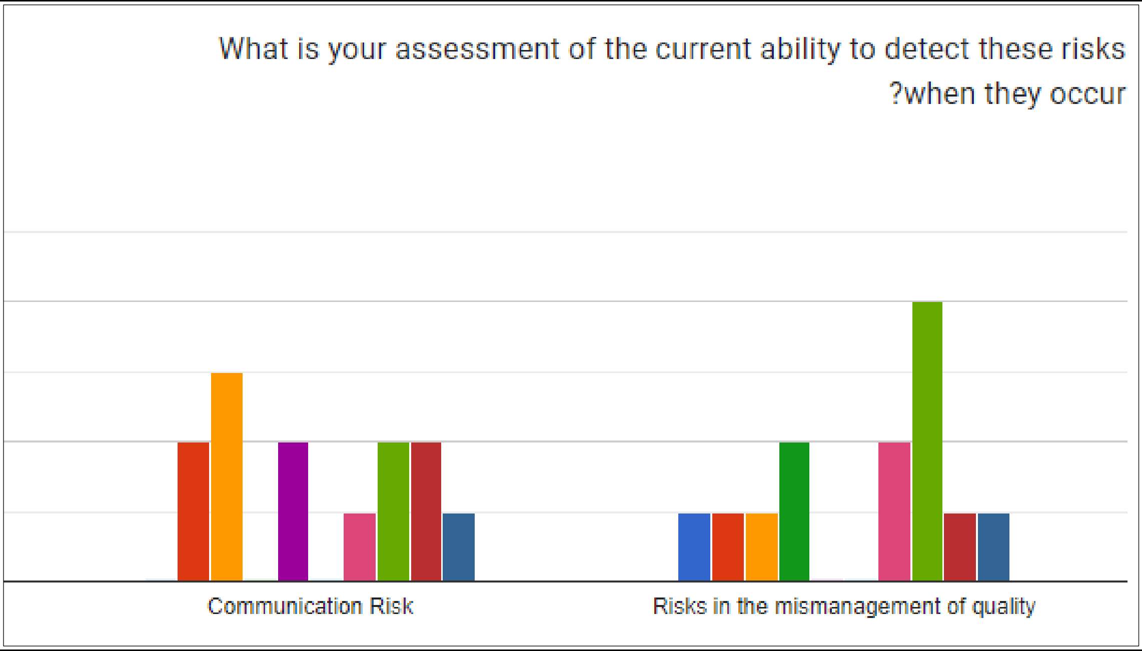
الشعبة In List (عامة., كهرباء., كيمياوي., مدني., معماري., ميكانيك., نفط.)

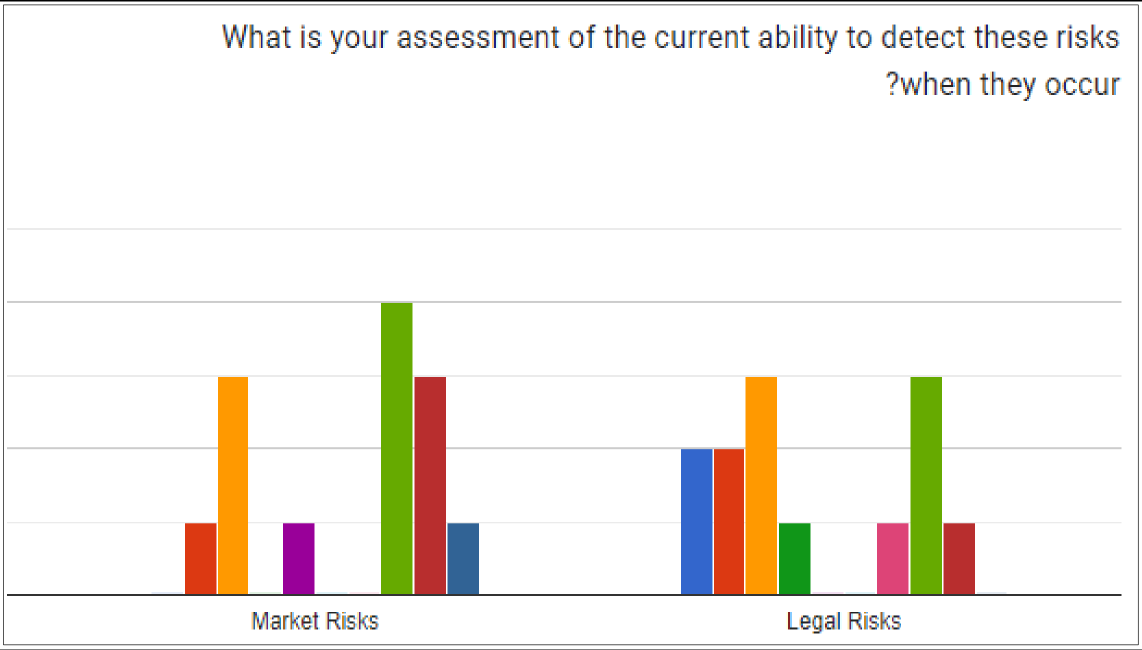
Appendix F

The appendix is the additional questionnaire form that was distributed to the participant, as below:

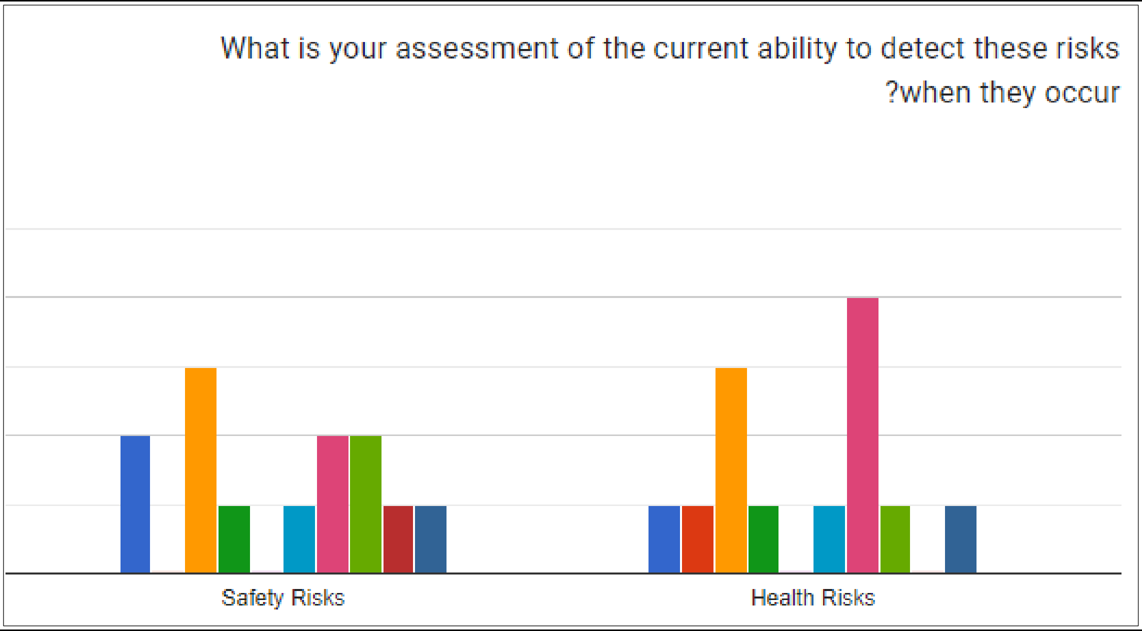
https://docs.google.com/forms/d/1f5fSOr1Y949oiBGS5AobC5lqTjnTaIQhr8mOiS1GgsM/edit



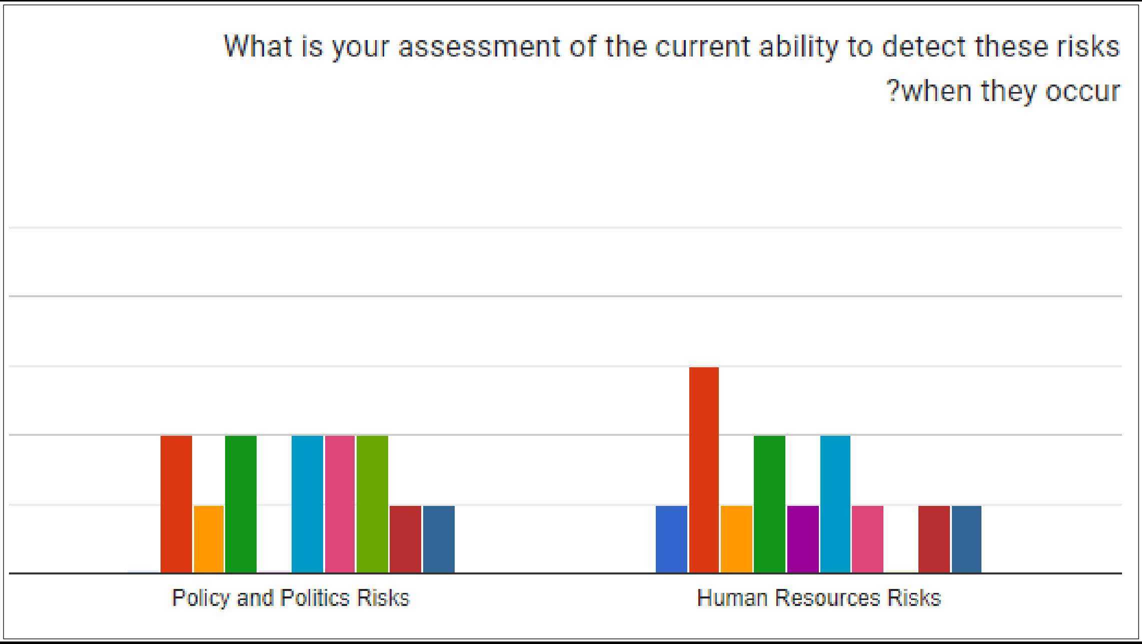


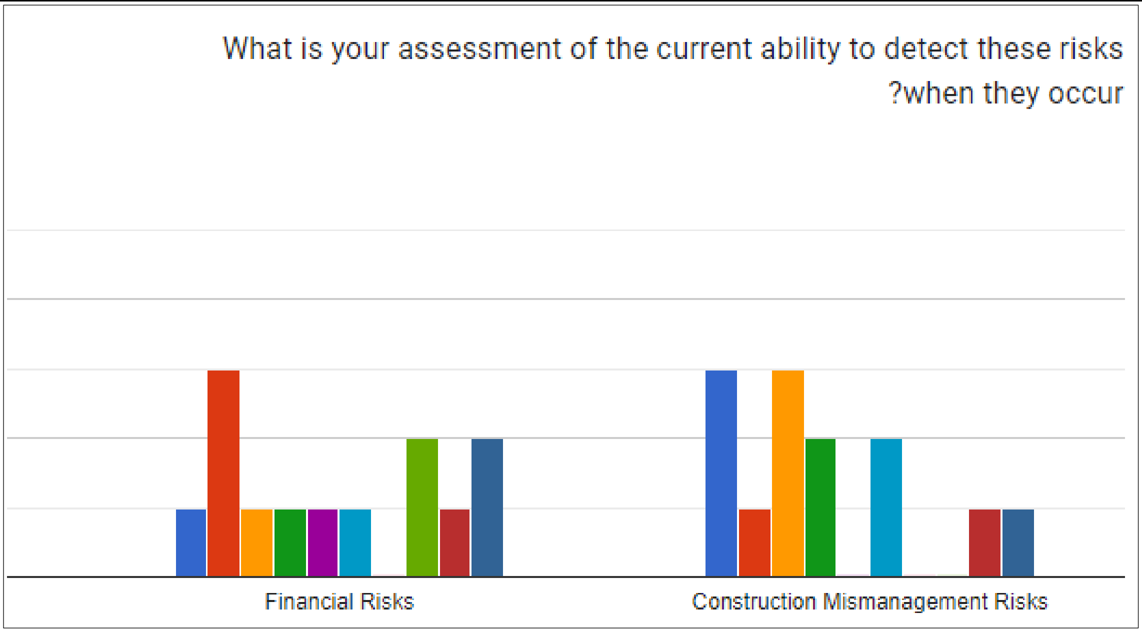


What is your assessment of the current ability to detect these risks ?when they occur
Market Risks
Legal Risks



What is your assessment of the current ability to detect these risks ?when they occur
Safety Risks
Health Risks


What is your assessment of the current ability to detect these risks
?when they occur
Policy and Politics Risks
Human Resources Risks


What is your assessment of the current ability to detect these risks
?when they occur
Financial Risks
Construction Mismanagement Risks

12/18/23, 4:04 AM   ملحق - استبيان مدى قابلية الاكتشاف لمخاطر المشاريع الانشائية بالعراق

ملحق - استبيان مدى قابلية الاكتشاف لمخاطر المشاريع الإنشائية بـ

هذا الاستبيان المبسط لتقييم مدى قابلية الاكتشاف للمخاطر المحددة

* تشير إلى أن السؤال مطلوب

https://docs.google.com/forms/d/1sdc7OoMN2srq-I0UocmE_E97vYFUoBJoZO_mSgBuNw/edit   1/4

1. ما تقييمك لمدى القدرة على اكتشاف هذه المخاطر عند حدوثها *

What is your assessment of the current ability to detect these risks when they occur?

التقييم من ١ إلى ١٠ حيث ١ تعني أننا ليس لنا قدرة على اكتشاف المخاطر عند حدوثها، و ١٠ تعني أننا يمكننا اكتشاف جميع حالات حدوث المخاطر عند حدوثها

Please rate from 1 to 10 where 1 means we don't have any ability to detect risks when they occur, and 10 means we can detect all instances of risk occurring when they occur.

1= لا يمكن اكتشاف حدوث المخاطر في جميع الحالات ، 10 = يمكن اكتشاف حدوث المخاطر في كل حالات حدوثها

1= The occurrence of risks cannot be detected in all cases,

10 = The occurrence of risks can be detected in all cases of their occurrence

حدد دائرة واحدة فقط في كل صف.

	10	9	8	7	6	5	4	3
Technical Risks	◯	◯	◯	◯	◯	◯	◯	◯
Risks of Design	◯	◯	◯	◯	◯	◯	◯	◯
Communication Risk	◯	◯	◯	◯	◯	◯	◯	◯
Risks in the mismanagement of quality	◯	◯	◯	◯	◯	◯	◯	◯
Market Risks	◯	◯	◯	◯	◯	◯	◯	◯
Legal Risks	◯	◯	◯	◯	◯	◯	◯	◯
Safety Risks	◯	◯	◯	◯	◯	◯	◯	◯
Health Risks	◯	◯	◯	◯	◯	◯	◯	◯
Policy and Politics Risks	◯	◯	◯	◯	◯	◯	◯	◯
Human Resources Risks	◯	◯	◯	◯	◯	◯	◯	◯
Financial Risks	◯	◯	◯	◯	◯	◯	◯	◯
Construction Mismanagement Risks	◯	◯	◯	◯	◯	◯	◯	◯

Experts voting table on the probability of detecting risks (evaluation for all 12 risk groups). The first answer was deleted when calculating because it was experimental. (Supplementary questionnaire).

https://docs.google.com/forms/d/1f5fSOr1Y949oiBGS5AobC5lqTjnTaIQhr8mOiS1GgsM/edit

No	Timestamp	Ability to detect [Technical Risks]	Ability to detect [Risks of Design]	Ability to detect [Communication Risks]	Ability to detect [Risks in the mismanagement of quality]	Ability to detect [Market Risks]	Ability to detect [Legal Risks]	Ability to detect [Safety Risks]	Ability to detect [Health Risks]	Ability to detect [Policy and Politics Risks]	Ability to detect [Human Resources Risks]	Ability to detect [Financial Risks]	Ability to detect [Construction Mismanagement Risks]
1	10/29/2022 14:28:33	10	8	8	8	8	7	7	7	8	8	7	7
2	10/30/2022 0:27:21	1	3	2	3	2	3	10	4	4	10	10	10
3	10/30/2022 10:40:45	5	8	4	4	6	8	4	4	5	6	9	7
4	10/30/2022 12:21:29	1	2	3	4	3	4	5	4	2	1	2	2
5	10/30/2022 13:35:38	8	7	6	10	8	9	8	8	5	9	8	8
6	10/30/2022 15:17:48	8	10	9	7	2	9	2	10	7	7	1	8
7	10/30/2022 16:33:09	1	2	1	2	2	3	3	4	3	2	5	5
8	10/30/2022 16:33:52	9	4	8	3	3	3	3	3	3	4	3	5
9	10/30/2022 22:06:35	8	7	6	7	3	8	8	8	7	7	6	8
10	10/31/2022 0:15:44	10	9	9	9	9	10	10	8	9	9	9	10
11	10/31/2022 1:45:28	2	10	2	3	1	10	1	1	1	5	3	10
12	10/31/2022 1:46:21	2	1	3	3	8	8	8	9	9	9	9	9
13	10/31/2022 12:05:54	7	10	8	1	3	2	4	5	4	5	1	1

Publications during the Ph.D. Project

Paper 1;

Risk assessment on the construction site with the use of wearable technologies

Forat AL-Sahar, Aleksandra Przegalin´ska, Michał Krzemin´ski

In: Published by Elsevier BV on behalf of Faculty of Engineering, Ain Shams University. Ain Shams Engineering Journal, Volume 12, Issue 4, December 2021, Pages 3411-3417

Type: Journal article

Status: Published | Year: December 2021

DOI: https://doi.org/10.1016/j.asej.2021.04.006

Paper 2;

Practical Analysis and Response for Risks Using Monte Carlo Simulation on Construction Manufacturing

Forat AL-Sahar

In: Published under licence by IOP Publishing Ltd

Type: Conference article, IOP Conference Series: Materials Science and Engineering, Volume 661, XXVIII R-P-S Seminar 2019 9–13 September 2019, Žilina, Slovakia

Status: Published | Year: December 2019

DOI: https://doi.org/10.1088/1757-899X/661/1/012132

Paper 3;

The relation between the cost impact and mismanagement in the Middle East construction projects

Forat AL-Sahar

In: Published in Scientific Review Engineering and Environmental Sciences 28(2):203-211, Przegląd Naukowy Inżynieria i Kształtowanie Środowiska

Type: Conference article, Warsaw University of Life Sciences, Poland

Status: Published | Year: July 2019

DOI: https://doi.org/10.22630/PNIKS.2019.28.2.19

Paper 4;

Study of selected soil stabilization material and the cost impact

Forat AL-Sahar, Mohemmed Erdini

In: Published IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)

e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 16, Issue 5 Ser. II (Sep. - Oct. 2019), PP 56-61

Type: Journal article

Status: Published | Year: oct 2019

DOI: https://doi.org/10.9790/1684-1605025661

Paper 5;

Practical application of Eurocode provisions to design a steel frame of a building classified to the upper risk group

Wioleta Barcewicz, Forat Al-Sahar

In: MATEC Web of Conferences 262, 09001 (2019), Krynica 2018

Type: Conference article

Status: Published | Year: 2019

DOI: https://doi.org/10.1051/matecconf/201926209001