IMPACTS OF CONSTRUCTION MATERIAL DELAY IN IRAQ

by

OMAR RAAD ABDULLAH

Presented to the Faculty of the Graduate School of

The University of Texas at Arlington in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF SCIENCE IN CIVIL ENGINEERING

THE UNIVERSITY OF TEXAS AT ARLINGTON

DECEMBER 2019

ACKNOWLEDGEMENTS

I would like to express my appreciation to Dr. Mohammad Najafi, Ph.D., P.E., ASCE Fellow, Director of the Center for Underground Research and Education (CUIRE) and Professor at The University of Texas at Arlington, for his continuous and valuable support and guidance throughout my academic and research work. It has been a pleasure working under him in various projects during my graduate studies, including this thesis. I would like to thank all my professors at the University of Texas at Arlington for their efforts during my study. Specifically, I would also like to acknowledge the members of my graduate committee, Dr. Sharareh Kermanshachi, P.E., and Dr. Mostafa Ghandahari, P.E., for serving on my committee and taking the time out from their extremely busy schedules to attend my thesis defense.

Additionally, I would like to thank all the survey respondents for their time and efforts to provide valuable information regarding project delays due to shortage of material in Iraq. Special thanks go to my father, Raad Abdullah, for his love and support, and to my mother, wife, brothers, sisters, and relatives for supporting me throughout my life. I would like to especially thank my father to whom this thesis report is dedicated with lots of love.

December 4, 2019

ABSTRACT

IMPACTS OF CONSTRUCTION MATERIAL DELAY IN IRAQ

Omar Raad Abdullah, M.S.

The University of Texas at Arlington, 2019

Supervising Professor: Mohammad Najafi

The construction industry is considered one of the most important industries in Iraq. It is well known that most construction projects in this country can experience missed deadlines and cost overruns or both. The main objectives of this study are to evaluate the impact of construction material shortages and to determine the most important problems causing these shortages in Iraq.

The above objectives are achieved through a literature review and a survey, which include a questionnaire used to assess the perceptions of the main participants involved in the construction of different types of projects, such as infrastructure, residential, highways and medical projects. This questionnaire is divided into two parts. The main part focuses on evaluating the impact of material shortages on delay by comparing it with other delay factors. The questionnaire includes 20 factors based on the literature review. Answers are collected from 50 participants, including project managers, contractors, consultants, project engineers and academic experts involved in construction. The second part of the questionnaire focuses on finding and evaluating main problems leading to a shortage of material after categorizing the problems into four main parts of technical, experience, management and government problems. The analysis is carried out to evaluate the weight

of material shortages when compared to other delay factors and to evaluate the main problems that lead to a shortage of material.

The results of this thesis conclude that problems most likely to cause a shortage of construction material in Iraq are the lack of experienced employees (unable to understand specification requirements at customs), lack of experienced owners or supervisors to manage existing material factories (experience problem), lack of material managing system in the projects (major management problem) and the shutdown of local material production plants (due to government laws).

Table of Contents

List of Illustrations

List of Tables

Chapter 1 Introduction

1.1 Background

The construction industry is one of the most important industries due to its substantial contribution to the economic development of a country. It is a highly dynamic sector and plays a vital role in the socio-economic growth of a country (Memon, 2013 & Nagapan, 2014). Construction projects enhance the quality of life in the surrounding community by providing necessary facilities such as roads, hospitals, schools, and hotels. Thus, it is important to make sure construction projects are completed successfully within time, budget, and desired quality.

Iraq is the third-largest exporter of oil in the Middle East after Saudi Arabia and Iran (OPEC, 2019). The oil market contributes greatly to Iraq's economy, such that after 2003, Iraq began experiencing rapid construction growth in all aspects of construction projects in both urban and rural areas (Samargandi et al., 2013). Thus, Iraq has one of the largest construction markets in the Middle East in both its public and private sectors. The public sector pertains to the government ministries responsible for infrastructure and national development projects. The private sector is comprised of privately owned construction projects or subsidized by either a family corporation or a conglomerate (Nashwan & Nagapan, 2015).

The Iraq construction industry is the second-largest sector contributing to Iraq's economy-second only to oil. According to the Iraqi Ministry of Planning, the construction industry comprised 30% to 40% of the non-oil productive sectors at the end of each national development plan from 2004 to 2018. The government progressively allocates huge amounts of money to develop myriad construction projects all over the country and in all the major cities. Many challenges face the Iraqi construction industry, and one of them is the project delay issue.

A study conducted by the Iraqi Ministry of Construction in 2015 found that around 70% of all public sector construction projects were delayed due to several factors in construction projects in Iraq (Mohammed, 2107). In addition, Bekr (2016) mentioned that one of the major issues responsible for Iraq's construction industry problems is delays in meeting project deadlines. Thus, it is very important to address the factors causing construction delay to ensure the success of construction projects in Iraq. This study focuses on the relationship between material shortages and delays occurring during Iraqi construction projects as well as the problems causing material shortages.

1.2 Iraq Economy Background

The economy of Iraq is based on oil and gas resources collectively but also on religious tourism, hospitality, real estate market taxes, construction, banking, shipping and trading sectors. Iraqi's economy has also been affected by the war crisis, and all of these sources of revenue have been negatively impacted. Moreover, a major input of the Iraq economy is based on direct foreign investments in oil fields or the construction industry which, which was reduced considerably after the wars. Similarly, tourist activities and the real estate's market were severely affected. Because the general Iraqi economy is dominated by the oil sector, the economy is struggling to return to normalcy. After experiencing war's effect on the oil industry, which has provided about 99% of the country's foreign exchange earnings in modern times (OPEC, 2018).

1.3 Iraq Social background

The people who live in Iraq include several ethnic groups and languages. According to 2018 estimates, the total population of Iraq is about 30,000,000. About 77% are Arabs, about 19% are Kurds and the rest are a variety of different groups, including Turkmens, Assyrians and Armenians. In Iraqi society, there are effectively three classes: the higher class, composed of well-known, influential families, the middle class, composed

of government employees, prosperous merchants, the military and others and the lower class, comprised of peasants and laborers. 95% of Iraqis are Muslim, 3% are Christian and 2% make up multiple religions.

Iraq is naturally of great importance to the Muslim world and is home to many significant religious tourist sites, such as the Al ‘Askari and the Al-Abbas Mosques in Samarra and the Gilani Mosque in Baghdad. However, from the Iraqi harbor’s extreme north to its extreme south, every region of the historical site is revered by other religions, including Christians, Jews, Yezidis and others. The Ninawa province abounds in early Christian churches, and a Christian church from the 5th century has been found near the city. Kerbela and Najaf are the main cities for religious tourism, which is a very important income for the Iraqi economy. Some religious tourist attractions are venerated by more than one religious’ group. For example, Zul-Alkufl in the province of Babel is both a Jewish and a Muslim historic site. The tomb of the prophet Younes (Jonas) in Mosul is visited by Christian, Muslim, and Jewish faiths. Many of Iraq’s minority faiths can also trace their origins to locations in Iraq.

1.4 Problem Statement

Construction activities are subjected to the influence of highly changing variables and unpredictable factors, which may affect construction success. The variabilities are from different sources such as the performance of different construction entities representing the industry’s most important projects, resource availability, material availability, environmental conditions, the involvement of outside interests, contractual relations, design errors, unexpected site conditions, increases in project scope and other project changes. Because of the effect all of these factors have on the success of any construction project, construction industries worldwide expect problems. The most common problem is

delays due to lack of inventory, lack of prompt delivery, inefficient management systems and many other conditions to be defined in this thesis.

In Iraq, delayed construction projects are the most pressing problem facing the construction industry, and it has given the construction industry a harmful negative image. This negative impact has motivated many researchers (Assaf et al., 1995; Al-Khalil & Al-Ghafly, 1999; Assaf and Al-Hejji, 2006; Al-Kharashi & Skitmore, 2009; Alotaibi et al., 2014; Elawi, 2015) to explore the construction delay issue. These previous studies identified several factors causing construction delay and most of them had a high impact on the construction industry in Iraq. Bekr (2016) conducted an important study that identified delay factors related to public projects using statistical analysis, but it did not consider the relationships between the factors and the delay itself.

Since Iraq experiences rapid development in all kind of construction projects, the identify of significant delay factors is essential to these projects success. This study focuses on the shortage of construction material and evaluates the importance of these factors as well as the problems that lead to this factor. Therefore, this study identifies the impact of material shortages on the delay in construction and compares the weight of this factor to other factors. The study evaluation was done to identify the problems that lead to material shortages in construction projects.

Identifying the major causes of material shortage can help control the impact of potential delays in the Iraq construction industry. Better control of material shortages can lead to more successful future projects due to better management of inventory and ordering, which will naturally lead to better control over the ability to meet deadlines and complete projects on time.

1.5 Objective

The aim of this study was to evaluate the impact of material shortages on delays in Iraqi construction projects. To achieve this aim, the following tasks were set:

1. Evaluate the weight (full value of delay effect) of material shortages as they relate to the main delay factors in the Iraqi construction industry.
2. Evaluate the most important problems leading to material shortages.
3. Rank material shortages into four major categories: technical, experience, management, and government laws.

1.6 Scope of the Research

This study was carried out in the United States as part of the thesis research conducted by Omar Abdullah, an Iraqi citizen and MS candidate at the University of Texas at Arlington (UTA). The study focuses solely on the construction industry of Iraq. All respondents of this study's survey questionnaire (given to get feedback on the delay factor and other problems in the Iraqi construction industry) were construction experts. These experts were currently involved or had a history of recent involvement in Iraqi construction. Many were also involved in the academic side of construction education and development.

This study adopted a quantitative approach where the collected data were obtained from recent studies and research, construction organizations, government reports and construction experts, including contractors, consultants and project management partners (in administration, management and operations). Thus, most participants had served or were serving as project managers, project engineer or academic experts. A survey questionnaire has been used to extract the knowledge and experience of the selected respondents. The collected data from the survey was analyzed using the AHP (Analytic Hierarchy Process) software (Saaty, 2008; Peng, 2011) and the important index (IMPI) method (Soni, 2017) to establish the evolution and the weight of the material

shortages factor and the problems that lead to it. Table 1.1 shows the scope of work in detail.

Table 1.1 Work Scope

Topic	Included	Not included
Type of material	X	-
Production location	X	-
Entities causing delay	X	-
Construction material shortages and evaluation of the importance of this factor in delaying construction projects	X	-
Material shortage effects on delays in construction and the weight of this factor as it relates to other delay factors	X	-
Evaluation of problems leading to shortage of material in construction projects	X	-
Specific cities	-	X
Countries other than Iraq	-	X

1.7 Thesis Structure

The thesis for this study consists of five chapters as follows:

Chapter 1: Introduces and describes the reasons for this study. It contains background information, a problem statement, an aim & objectives, and work scope.

Chapter 2: Provides an overview of the Iraq construction industry and also focuses on detailed reviews of previous research related to delay issues as they apply worldwide and to the Iraqi construction industry in particular. All information was gathered to provide a comprehensive understanding of material shortage issues and their impact on delays in construction projects.

Chapter 3: Explains the methodology adopted for carrying out this research work. It also presents details about the methods used for data collection as well as analysis techniques.

Chapter 4: Explains the development processes of the AHP (Analytic Hierarchy Process) method (Saaty, 1980, 2008; Peng et al., 2011) and the assessments carried out on establishing a structural relationship model between the material shortages factors and other delay factors. This study also identifies the problems that can lead to a shortage of material.

Chapter 5: Concludes the overall findings of this study. It also discusses the limitations of the study and provides recommendations for future research.

Chapter 2 Literature Review

2.1 Introduction

This chapter provides a general overview of the Iraq's construction industry, and it provides a detailed literature review related to construction delay issues, including definitions, types, effects and construction delay factors. The focus in this chapter will be the impact of the material shortage on project delay, the literature review also covers issues related to construction delay factors globally as well as in Iraq.

2.2 Iraq's Construction Industry

Iraq is one of the most famous countries in the Middle East. It is located in Western Asia, bordered by Turkey to the north, Iran to the east, Kuwait to the southeast, Saudi Arabia to the south, Jordan to the southwest and Syria to the west. The capital, and most populated city, is Baghdad, which covers an area of 168,754 M^2 and has a population of 39,485,000 people. Iraq has famous cities with high populations like Baghdad and Mosul, economic cities like Basra and Kirkuk, Islamic tourism cities like Najaf and Karbala and tourist cities Like Erbil and Duhok (Khadduri et al., 2019).

People from many countries travel to Iraq for many reasons, often for investments, tourism, and trade and many other reasons. Almost all Iraqi hotels are fully occupied year-round.

Figure 2.1 Baghdad City Centre Baghdad City Center, Available at: www.skyscrapercity.com (Accessed on October 20, 2019)

Because of the reconstruction process, construction machinery, equipment, and material (especially cement and the steel bars needed for reinforcement) will continue to be in high demand in the coming years (Iraqbuild.org). Table 2.1 will show the planned budget for construction projects in Iraq between 2020-2025.

Table 2.1 Iraq's Reconstructing Plan 2020-2025
(Iraqbuild.org) Accessed on 10/25/2019

Project Types	Projects Budget ($)
157 Infrastructure construction projects	100 B
Power plants development	600 M
Residential and housing projects	6 B
Medical projects	200 M

According to the Iraqi Ministry of Planning, almost 107 billion dollars will be spent on the reconstructing of Iraq (Iraqibuid.org), this huge amount of construction will need continuous availability of all kinds of construction material. Local production cannot even cover 10% of the required material, so the construction industry will face huge material shortages based on material inventories. Figure 2.2 will show the Iraq building plan for 2020-2025 as a chart view.

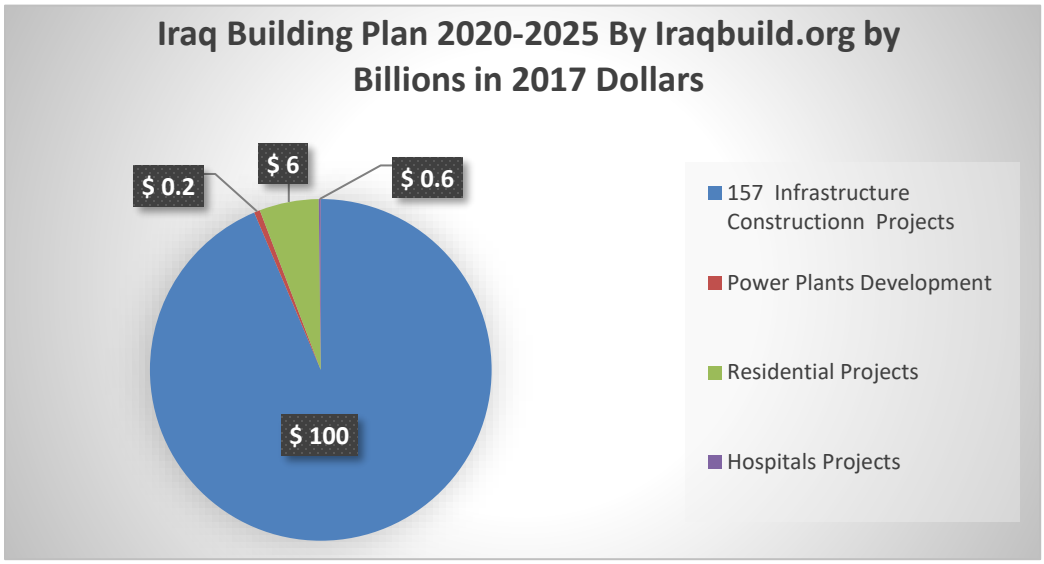


Figure 2.2 Iraqi Building Plan 2020-2025
(Iraqbuil.org) Accessed on 10/25/2019

Furthermore, immediate delivery from any country is a bottleneck that is well documented by the questionnaire survey processed as part of this research. This built-in material shortages situation leads directly to project delay problems-often for unknown delay periods.

2.3 Delay in Construction Industry

Delay is the biggest and most devastating problem facing the construction industry. Delays are directly involved in failure or success or construction projects. Many factors in the construction industry will lead to a delay in the construction industry (Assaf, 2006). Delays happen in most construction projects, whether simple or complex. Construction delay could be defined as the time overrun either beyond the contract date or beyond the date that the parties agreed upon for delivery of a project (Assaf, 2006).

Even with today's high technology project management, delays are still an integral part of most construction projects. Reasons for the delay include poor management, lack of experience from those in management and those doing the labor, material shortages, financial problems, change orders, equipment failure, acts of God (natural disasters) and many other unforeseen interruptions, such as failures in communication or lack of reliable suppliers. Delays are often interconnected, making the situation even more complex (Assaf, 2006).

Although delays are a common trait of all construction projects, its magnitude varies from one project to another ranging from days to months and even years (Masood et al., 2015).

2.4 Characterization of Construction Delay

Delay is acknowledged as the most common, costly, complex and risky problem encountered in construction projects (Shi et al., 2001). Numerous studies and research projects have contributed to defining the concept of construction delay (Serajiantehrani, et

al., 2019). Many articles have identified delays caused by time overrun, which required an extended time to complete construction projects, resulting in a delayed project completion date (Al-Hejji, 2006).

One of the major issues engulfing the construction industry is a delay in completing a project within the agreed duration (Nashwan & Nagapan, 2015). Pai & Bharath (2013), defined delay as a slowing down of work without stopping it entirely.

Delay also refers to an overly long construction period due to problems that occurred during the implementation of the project (Kikwasi, 2012). According to Hasan et al., (2014), delays in construction can be defined as postponing the project completion time due to either predicted or unpredicted causes or both. Based on Rahman (2014), a delay can be defined as the late completion of activities on a planned schedule due to excusable and non-excusable delays. According to Alotaibi at al., (2014), delays are defined as incidents that lead to an extension in the time agreed upon within a contract to complete a project. For an owner, a delay means the loss of income and the unavailability of facilities. For contractors, it means loss of money due to extra equipment costs, material, hiring of additional labor and loss of time (Haseeb et al., 2011).

According to past studies, definition of delay in construction projects for this study can be stated as the failure to achieve project milestone activities as planned due to different effective factors. The main study factor will be the shortage of construction material.

2.5 Types of Construction Delays

Many research projects and studies have tried to define the main types of delay globally and locally and to categorize them accordingly. According to Ahmed et al., (2002), Menesi, (2007), and Hamid et al., (2015) delays can be grouped into four main categories based on contractual frameworks as follows:

1. Non-Excusable Delays
2. Excusable Non-Compensable Delays
3. Excusable Compensable Delays
4. Concurrent Delays

And we can simply define each type as follows:

1. Non-Excusable Delays: This is caused solely by the contractor or his suppliers due to an occurrence that was within the Contractor's control (Gardezi et al., 2013).
2. Excusable Non-Compensable Delays: This occurs when neither the owner nor the contractor is responsible for the delay. Such as an act of God (Tumi et al., 2009).
3. Excusable Compensable Delay: This delay is caused by owner or the owner agent.
4. Concurrent Delays: This happens when two or more delays happen at the same time and the impact can be experienced separately or combined.

The most interesting delay is caused by construction material, which can be caused by all types of delay (Serajiantehrani, 2019). The shortage of material could due to negligence or mishaps by the owner or contractor or by an act of god or other reasons. So, the proper management of material is essential for controlling delays. Delays attributes and types will be shown in 2.2 and the definition of type.

Table 2.2 Delay Attributes and Types (Hassan 2016)

Delay Categories	Definition
Related to owner (Excusable compensable delays)	Decision making, suspension of the work, revising and approving the document, financial, change of order, delivery of the site
Related to consultant (Excusable, compensable delays)	Lack of experience, late submittals and approval of documents, poor communications, lack of inspection, error in the design and drawings

Table 2.2 continued

Related to contractor (Non-excusable delays)	Financial, poor management, lack of experience, lack of safety, lack of training, poor communication, improper construction method, and lack of experienced staff

Table 3.2 presents some factors attributes to all kinds of delays.

Table 2.3 Some Factors Contributing to All Types of Delays

Delay Categories	Definition
Related to material all types of delay	Shortage of labors, unqualified workforce, low productivity of labors, training
Related to labor	Shortage of labors, unqualified workforce, low productivity of labors.
Related to construction site	Shortage of material, problems with delivery of material, changes of specifications and types of material, inflation and escalation of prices

2.6 Factors and Causes of Delays in Construction Projects

There are several reasons for delays in construction projects, some are expected and some are not, many researchers tried to identify the most prevalent delays in construction projects, and each study identifies the causes depending on the type of the project and the area of study. In this study, the literature review is related to worldwide construction delay issues based on construction projects in different countries around the world. These studies found 43 common factors causing construction delays as summarized in Table 2.4.

Table 2.4 Delays Factor in Worldwide Construction Industry (Nashwan 2016)

No.	Factors causing construction delay	References
1	Unrealistic contract duration	Mahamid (2014)
2	Unrealistic requirements imposed	Al-Kharashi & Skitmore (2009)
3	Type of construction contract	Assaf et al. (1995)
4	Overdependence on the lowest bidder amount in contractor selection	Albogamy et al. (2012); Albogamy, et al. (2013); Mahamid, (2013)
5	The scope of the project is not well defined	Al-Khalil & Al-Ghafly, (1999); Assaf and Al-Hejji (2006).

Table 2.4 Continued

No.	Factors causing construction delay	References
6	Inadequate project structure	Al-Kharashi & Skitmore (2009)
7	Poor contract management	
8	Inadequate early planning of the project	Albogamy et al. (2012)
9	Inadequate early scheduling of the project	Albogamy et al. (2012)
10	Lack of teamwork	Assaf and Al-Hejji (2006)
11	Interference by owner in construction operations	Al-Kharashi & Skitmore (2009)
12	Late in approving design documents by owner	Masood et al. (2015)
13	Shortage of construction material	Fugar (2010)
14	Suspension of work	Al-Kharashi & Skitmore (2009)
15	Delay in approving shop drawings by owner	Assaf et al. (1995)
16	Delay in approving material samples	
17	Variations orders	Alotaibi et al. (2014) & Mahamid (2014)
18	Delay in issuance of change orders	Assaf et al. (1995)
19	Slowness of the owner's decision-making process	
20	Owner's failure to coordinate with Government authorities during planning stage	Al-Khalil & Al-Ghafly, (1999)
21	Delay in progress payment by owner	Assaf et al. (1995)
22	Poor communication between owner & others	Al-Kharashi & Skitmore (2009); Mahamid, (2013) & Mahamid, (2014) Assaf and Al-Hejji (2006);
23	Rework due to poor quality works by contract	
24	Owner's failure to coordinate with Government authorities during planning stage	Al-Khalil & Al-Ghafly, (1999)
25	Lack of high-technology mechanical equipment	
26	Delay in equipment delivery	Al-Kharashi & Skitmore (2009)
27	Unqualified workforce	Assaf et al. (1995) & Mahamid (2014)
28	Lack of high-technology mechanical equipment	Al-Kharashi & Skitmore (2009)
29	Shortage of manpower	Assaf et al. (1995)
30	Labour Absenteeism	Assaf and Al-Hejji (2006)
31	Delay in obtaining permits from Municipality	Assaf and Al-Hejji (2006) and Emam et al. (2014)
32	Bureaucracy in Government agencies	
33	Effect of weather	
34	Shortage of Technical Professionals	Al-Kharashi & Skitmore (2009); Albogamy
35	Inadequate Contractor Experience	Albogamy et al. (2012); Albogamy et al.
36	Ineffective monitoring of the project progress by the contractor.	Al-Kharashi & Skitmore (2009)
37	Land acquisition	Assaf and Al-Hejji (2006)

Table 2.4 Continued

No.	Factors causing construction delay	References
38	Traffic control of the project	Assaf and Al-Hejji (2006)
39	Logistic access to site	
40	Changes in government regulations and laws	
41	Economic instability	Al-Kharashi & Skitmore (2009)
42	Political insecurity	Assaf and Al-Hejji (2006)
43	Land acquisition	

Table 2.4 does not reflect all the causes of the delay in the construction projects, but it does reflect some of the main causes, because each project is unique and has different conditions, so some of the causes will be different from project to project depending on the project type and conditions. Iraq has been selected as area of study to show that unstable politics in this country related strongly to construction delays. Moreover, the wars crisis that happened in Iraq from 2003 until 2016 had a huge effect on many projects' progress and delays. As mentioned before. Table 2.1 shows some of the delay causes in the construction project; however, the main focus in this study was the delays caused by material shortages and the types of problems related to material.

2.7 Impact of Delay on Construction Projects

Construction delays impact the time and cost of projects (Pressoir, 1992). Cost and time overruns, followed by various claims, have become an integral part of construction projects worldwide. The question is no longer whether there will be claims, but how serious will they be (Pressoir, 1992). A construction project is usually considered successful if it is completed on time, within its budget, and successful in achieving its quality targets. One of the main duties of the construction project manager is to ensure that the project does not exceed its allotted cost and time frames despite claims (Sambasivan and Soon, 2007). In the next chapters, the cost not meeting time and cost constraints will be discussed

considering past studies and research, while acknowledging the effect of continuous problems in the construction industry.

2.8 Project Time Overruns

Not meeting timeline deadlines (time overruns) is one of the most serious issues in the construction industry globally. Timely completion is the key criteria for achieving success in any project. Construction time overruns are the change between a project's actual contract period at the time of tendering (offering a bid) and it's final contract period in which the construction project is finished. Time overruns can result in many negative impacts on the construction project like budget overruns, low productivity, contract expiration and work acceleration resulting in bad quality and disputes among construction stakeholders. Notably, many construction projects face the issue of time overruns worldwide both in developing and developed countries like the USA and the UK and as well as in other prosperous fast-growing countries.

More than 40% of projects in the construction industry experience time overruns. The construction industry is not well known for its ability to complete a project on time. Ignorance of time overrun analysis has resulted in many construction projects failing to complete construction within the given time frame (Duran, 2006). Only 47% of the projects were completed within the approved time frame. Around 38% of construction projects had missed the goals set up within their time frames and 15% of construction projects were completed ahead of time (Apolot et al, 2011).

Unfortunately, the construction industry in Iraq has been labeled as an industry facing poor performance leading to failure in achieving effective time management. Consequently, most projects face a huge amount of time overruns. Many researchers have conducted studies on the causes of time overrun in different types of construction projects to find the factors and causes of time overrun. Fugar, 2010 identified causes of time overrun

as delayed payments, material shortages, changes in selected material prices, poor site management and problems with finances due to poor supervision at the site and site, delay in making decisions. Other causes of time overruns have to do with, owner interference in the project, ground conditions and necessary changes from the owners. All these parameters have been identified by past studies as the major causes for time overrun (Chan, 1996). The developing countries are continuously facing time overruns continuously of lack of experience, management, material and planning.

2.9 Methods for Identifying the Delay

Many methods and techniques have been used to identify and calculate the delay in the projects. Some of the most well-known methods will be described in the next section.

2.9.1 The critical path method CPM:

The critical path method (CPM) is the most well-known method used to analyze the effects of schedule delay (Bordoli and Baldwin, 1998). Usually, delay analysis is performed by comparing the as-planned schedule and the as-built schedule (Kraiem and Diekmann, 1987). This study involves in an investigation of three currently accepted delay analysis methods. These are the “what-if” method, the “but-for” method and the contemporaneous period analysis CPA method. These differ in the baseline schedule against which delay effects are measured. The critical path method (CPM) is widely used to analyze the effects of schedule delay (Arditi, 2001).

Delay analysis is most commonly performed by comparing the as-planned schedule and the as-built schedule (Arditi, 2001). This study investigated three currently accepted delay analysis methods. These are the “what-if” method, the “but-for” method and the contemporaneous period analysis (CPA) method. These differ in the baseline schedule against which delay effects are measured.

2.9.2 What-if method:

The what-if method adopts the anticipated or as-planned schedule as its baseline. First, the delay is said to be attributable to one side and is added to the as-planned schedule. The impact on project duration due to these delays is determined. This process is repeated for the delays attributable to the other side. Finally, we determined the amount of delay in the total project duration that can be considered attributed to each side (Arditi, 2001).

2.9.3 But-for method:

It adopts the as-built schedule for its baseline. This method overcomes the inadequacy of the what-if method for dealing with changes in project planning and execution during construction. But for the method subtracts the delay attributable to the owner from the as-built schedule. The compensable delay is the difference in duration between the as-built schedule and the but-for schedule (Arditi, 2001).

2.9.4 Contemporaneous Period Analysis (CPA) method:

The CPA method breaks the construction period into discrete time increments and examines the effects of the delays attributable to each of the project participants as the delays occur. This method effectively characterizes and quantifies delays on construction projects. It adopts the as-planned schedule as its baseline, but the as-planned schedule is periodically updated at the end of each planned time increment, and the updated schedule becomes the baseline for ensuring time the increment. This process of periodic schedule updating is continued through to the project completion (Arditi, 2001). Courts have generally accepted this method of schedule delay analysis because the method can concretely express project delay as compensable delay, non-excusable delay and excusable non-compensable delay (Frimpong et al, 2003).

According to the previous data collected and past research, found that the overrun of a project means more time than the expected time. These changes in the time of a project refer to the delay of a project; moreover, sometimes the delay is excusable, and sometimes, it is not excusable. Nevertheless, both situations still delay the project. In the construction industry, however, there is no single standard or “accepted” procedure to determine the impact of schedule delay due to change orders or other unplanned developments (Frimpong et al, 2003).

2.10 Project Cost Overrun

The delays impact on construction projects refers to both cost and time overruns, and these problems have long been common problems in the construction and engineering sector. The increase in the cost of big projects has become a well-known global issue. With no reduction in the last 70 years, an average cost overrun of 28% is expected (Flyvbjerg et al, 2002). Optimistic expectations of time and budget have been found to decrease quality and productivity during construction and after the completion of the final product (Park et al., 2010). To reduce such overruns, the existing body of knowledge tends to focus on critical success factors associated with time and cost as individual concepts of different project types and geographical regions, providing an unsatisfactory frame of reference.

Over the last few decades, much research has been focused on the factors that affect cost performance in the construction phase of projects. Usually, the vast majority of cost overruns occur during the construction phase, in which many unforeseen factors are conceived over the conception/design stages (Kumaraswamy, 1997). Attributes such as poor site management and supervision, low speed of decision-making and client-initiated variations have reportedly been some of the most significant causes of cost overruns in the construction phase of projects (Trost and Oberlender, 2003). These factors affect the time of the project due to the delay and any delay in a project means more cost.

These factors are related to project management and it involves managing resources such as workers, machines, money, material and methods during this period (Frimpong et al., 2003). Although tools and techniques have been used to obtain a better understanding of the negative factors defined by (Trost and Obertender, 2003), leading to analyses on the effect of these factors on project delay and the relation of the delay to the increase of the cost in the project. In Iraq, construction projects continue to face huge uncontrolled delays leading to the increase of project costs and sometimes the failure of projects.

2.11 Construction Material

The simple definition of construction material is any material which is used for construction. Construction material is the focal point of the construction industry. Without material, there can be no construction.

After 2003, Iraq became a huge market for construction material. The market was always asking for material. All the countries around Iraq were starting to export construction material to Iraq, even some of the biggest factories in other countries started to produce and sell only to Iraq. The market was unstable due to different causes such as unstable politics, unstable government laws, lack of safety, unstable border laws, changing codes, code requirements, lack of experience, lack of management, an unstable stock market, financial problems and many other problems. Any problem facing the material section led to a direct delays in the projects.

As previously mentioned, material are usually a part of all types of delays, which are sometimes controlled and sometimes uncontrolled. Material markets face continuously face social, political and economic problems. Because of the unstable politics and government situations, the market became uncontrolled locally. Whenever the source of

material follows and creates project requirements, the need to change according to the production source was the biggest problem facing the market between 2003 and 2010.

2.12 Construction Material Management

Construction material management is generally recognized to be the integrated coordination of material takeoff, purchasing, expediting, receiving, warehousing and distribution (Bell, 1986). If any of these functions are not properly controlled and managed, the lack of control will lead to material shortages, surpluses, and cash flow problems. Costly labor delays and costly equipment delays happen when a shortage of material exists, moreover, a shortage can come about simply because the required quantity or quality of material was not available when needed. Training and preconstruction material planning and personnel orientation is important and should be considered as the main area of concern in each project. Complex online computer programs are used to coordinate the material management system. They are costly, but essential if the desired degree of control is to be exerted to prevent potential shortages, surpluses and cash flow problems (Bell, 1986).

According to the Business Roundtable (1982), the material management system is planning and controlling all necessary efforts to make certain that the right quality and quantity of material are available when needed. Material are appropriately specified in a timely manner and are obtained at a reasonable cost.

This report estimated that $82 billion was spent on material in 1979 as part of industrial, commercial and power plant construction. The report also estimates that more than 6% of all construction labor costs could be saved if material and equipment had been available at the work site when needed.

2.13 Summary

This chapter presented a comprehensive literature review that was carried out to understand the issues of construction delay and the main factors that cause it. This chapter started by providing an overview of the construction industry in Iraq. It also provided a detailed review of previous studies that were carried out in different parts of the world. Furthermore, it discussed the literature review of previous studies on construction delay problems which found many factors lead to delay. Also, it is explained the construction material and the relation of those material to the projects and the effect of the material and material management.

Many factors facing the construction industry lead to delays due to lack of management, lack of labor, lack of labor productivity, a shortage of material, unsafe site conditions, unstable politics and many other reasons, especially during the period between 2003 and 2016 when Iraq faced many war hazards. The effects of the war were at a high level and were especially hard on construction projects. When considering Iraq today, we are focusing on the impact of material shortages on the delay of projects. Construction material has always been an important factor in Iraq It is used as an economic factor, social factor, and political factor, and at the end of analyzing all of these factors, we can see how they directly affect the construction industry. Before 2003 Iraq was a big producer of construction material, and the production units covered all parts of Iraq. Currently, Iraq is in the process of restructuring. It has a high potential and provides a suitable environment for foreign investment in the country.

Chapter 3 Research Methodology

3.1 Introduction

After the 2003 war crisis in Iraq, the construction material industries were fully shut down for many reasons, some of which were mentioned in the survey and literature review. After the war, Iraq started importing most of its construction material from other countries like Iran, Turkey, Jordan and Saudi Arabia. Because of war-related issues, the market faced many problems, expected and unexpected, and the construction material market became strongly responsive to the political issues within the importing countries, and the construction marketing impact was often negative. Study's survey included questions and answers related to importing material from outside Iraq.

3.2 Methodology Introduction

Figure 3.1 presents a flow chart showing the systematic process used in this chapter to obtain, study, question, analyze survey results, discuss and recommend solutions to the problems of the construction industry in Iraq. This study adopted a qualitative research technique by first identifying the weight (importance) of material shortages compared to other delay factors. The literature review covered past research and studies, expert opinions and recommendations, as well as government reports. The number of reasons was revised based on discussions and recommendations with industry experts based on 20 reasons considered in the study.

To identify the main reasons for the construction industry's material shortages, a quantitative procedure was adopted by developing a survey questionnaire and applying analysis to the survey data using statistical methods.

3.3 Survey Design

In order to gather the necessary data required for our work analysis, the survey questionnaire approach was adopted as a means of gathering the required information as

explained in figure 3.1. The research aim was to evaluate perceptions of the respondents on the influence of material shortages in construction and the prevailing attitudes of the construction industry.

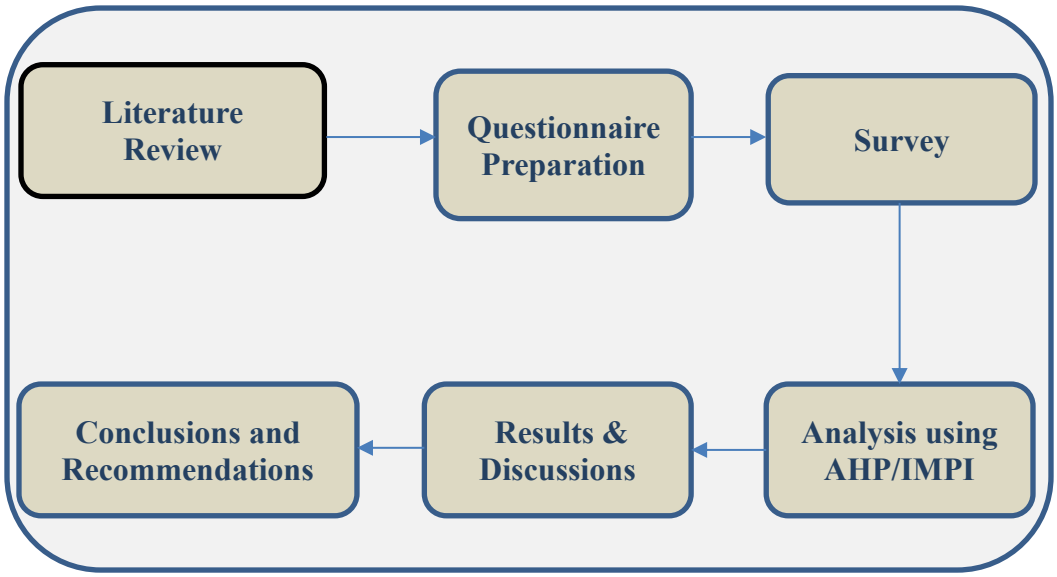


Figure 3.1 Methodology Systematic Processes

3.3.1 AHP Test

The Analytic Hierarchy Process (AHP) comparison was used to measure the survey questionnaire respondents choices, based on their organization type, job designation, industry type and total construction experience. Seven types of responder have been chosen, construction engineers, project managers, consultants, contractors, academic faculty, contractors and suppliers. Communication through email facilitated their participation in this survey. The survey is composed of two sections:

1. Weight of the material shortages as they relate to the 20 main factors designated as having led to delays.
2. Evaluation of the reasons that led to the material shortages experienced by respondents. This section is composed of 27 reasons divided into four categories

deemed to cause material shortages in construction and delays in construction projects identified from the literature review. The categories represent past studies and research, government reports and the opinions of industry experts. The respondents were requested to evaluate the attributes based on 5 options; where 1= Significantly Less Important, 2= Less Important, 3= Important, 4= More Important and 5= Significantly More Important.

For example, in the case of technical causes, the respondent was asked to evaluate the importance as important or not important based on whether or not the material shortage will impact the overall of construction projects.

The survey was sent to several contacts that play key roles in the construction industry. A total of 50 potential respondents were invited to participate in the survey and 50 respondents completed and responded to the survey.

3.3.2 A Statistical Approach to Ranking of Factors Test

This is the second test where used, the Importance Index Method (IMPI) to evaluate the shortage of material factors and the relation of these factors to other delay factors. The main reason for this test was to add additional test data and results and make sure the survey results will be treated in different ways throughout the test, which makes it eligible for more than one test type.

The procedures needed to achieve the Importance Index Method test contained two stages. The first stage was to find the Frequency Index (F.I), which was done using Eq.1 (Susmitha, 2018). In this case:

$$F.I\ \% = \sum a\left(\frac{n}{N}\right) * \frac{100}{4} \qquad \text{Eq.1}$$

Where, a= Weight is given to each response (ranging from 1 to 5)

n= Frequency of the response, N= Total number of responses

The second stage will be to find the Severity Index (S.I), which can be found using the S.I formula (A. R. S. Sri Susmitha, 2018), which can be expressed as:

S.V % = $\sum a\left(\frac{n}{N}\right) * \frac{100}{4}$

Where, a= Weight is given to each response (ranging from 1 to 5)

n= Frequency of the response, N= Total no. of responses

The criteria of the F.I to follow in the survey will be like following in Table 3.1.

Table 3.1 Frequency Index Table Form

Sl.no	S. Less Important	Less Important	Important	More Important	S. More Important
1	a=1	a= 2	a= 3	a=4	a=5

According to the study's survey structure ,different criteria names used, but for the same reasons and with the same meaning, the criteria has structured according to the importance degree to become eligible for the Frequency Index.

For the second part of the process the following criteria will be used which presented in Table 3.2.

Table 3.2 Severity Index Table Form

Sl.no	S. Less Important	Less Important	Important	More Important	S. More Important
1	a=1	a= 2	a= 3	a=4	a=5

According to the study's survey structure ,different criteria names used, but for the same reasons and with the same meaning, the criteria has structured according to the importance degree to become eligible for the Severity Index.

To achieve the Importance Index Method (IMPI) we will use the following formula (Susmitha, 2018), which can be given as:

Important Index % = [F.I % x S.I %]/100

where, F.I= Frequency Index, S.I= Severity Index.

Results presented in table 3.3

Table 3.3 Important Index Table Form

SL. No	SI %	FI %	IMPI %
1	= Result	= Result	=Result

3.4 Survey Data

The survey consists of two parts. The first part was designed to help evaluate material shortage delay factors. Twenty main factors were chosen to represent the most common problems in the Iraqi construction industry. Table 3.1 shows the factors that led to delays according to the recommendations, discussion and opinions of the survey's construction experts

The data for the second part of the survey were collected to evaluate the main issues leading to the construction projects material shortages. Data came from government sources, experts, construction-related organizations and academic sources. The data represents four main categories: Technical issues, government law issues, management issues, and experience issues. Tables 3.4 through 3.8 presents these four issues.

Table 3.4 Main Factors Leading to Delay in Iraq's Construction Projects (Not Ranked)

No.	Factors Causing Delay
1.	Unrealistic contract duration
2.	The scope of the project is not well defined
3.	Poor contract management
4.	Inadequate early planning of the project
5.	Inadequate early scheduling of the project
6.	Late approval of design documents by owner
7.	Suspension of work
8.	Delayed progress payment by owner
9.	Poor communication between owner and other parties

Table 3.4 Continued

No.	Factors Causing Delay
10.	Poor site management
11.	Poor qualifications of contractor's staff assigned to the project
12.	Shortage of material
13.	Delay in equipment delivery
14.	Delay in obtaining permits from municipality
15.	Effect of weather
16.	Project traffic control
17.	Issues in political security
18.	Issues in economic stability
19.	Changes in government regulations and laws
20.	Effects of subsurface conditions

Table 3.5 Technical Causes Leading to Shortage of Material
(Not Ranked)

No.	Technical Causes
1.	Lack of accurate specifications for the construction material at the customs office
2.	Lack of accurate code requirement for the construction material to follow at the customs office
3.	Lack of experienced employees to interpret the code requirements at the customs

Table 3.6 Experience Causes Leading to Shortage of Material
(Not Ranked)

No.	Experience Causes
1.	Unable to control bad quality and cheap material in the market
2.	Lack of management experience or supervision experience at the production plant
3.	Lack of experienced owners or investors to run the existing material factories
4.	Lack of experienced consultant and estimator to estimate the need of material
5.	Lack of experienced contractors to control construction material on site
6.	Lack of consultant to inform ordering entities about the availability of material in the market

Table 3.7 Management Causes Leading to Shortage of Material
(Not Ranked)

No.	Management Causes
1.	Lack of options for sources of construction material
2.	Lack of code updates according to the market
3.	Lack of project material managing system
4.	Lack of updated inventory and directives on the need for material during project operations
5.	Lack of proper planning for construction material storage
6.	Lack of proper storage for project material
7.	Lack of communication between the contractors and the consultants to update the material availability

Table 3.8 Government Laws Causes Leading to Shortage of Material
(Not Ranked)

No.	Government Laws Causes
1.	No limitations on specific brands or manufacturers for construction material imports
2.	Lack of the government laws on the marketing of construction material
3.	Lack of the government laws on imported construction material specifications
4.	Unstable government code requirement for material
5.	Different requirements for construction material specifications at each government location
6.	Continuous changes in government specifications for each project.
7.	Shutdown of local plants responsible for material production
8.	Corruption which prevented producers to make a profit from their imported products
9.	Lack of government support to run the private construction material manufacturing factories
10.	Lack of government plans to run the public construction material manufacturing factories
11.	Lack of government plans to build/develop new construction material manufacturing factories

3.5 AHP (Analytic Hierarchy Process)

The Analytic Hierarchy Process (AHP), introduced by Saaty (1980), is an effective tool for dealing with complex decision making and can help decision-makers to set priorities and make the best decision. By reducing complex decisions to a series of pairwise comparisons, and then synthesizing the results, the AHP helps to capture both subjective and objective aspects of a decision. In addition, the AHP incorporates a useful technique for checking the consistency of the decision maker's evaluations, thereby reducing bias in the decision-making process (Saaty,1980).

3.6 Benefits of AHP

Using AHP as a supporting tool for decision making will help construction management and other decision-makers gain a better insight into complex problems. AHP requires the user to structure the problem into a hierarchy, which forces him or her to think through the problem, consider possible decision criteria and select the most significant criteria with respect to the decision objective. Using pairwise comparisons helps to discover and correct logical inconsistencies. The method also allows "translating" subjective opinions, such as preferences or feelings, into measurable numeric relations. AHP helps to makes decisions in a more rational way and make them more transparent and understandable (Goepel, 2019).

3.7 AHP Method

Mathematically the method is based on the solution of an Eigen value problem. The results of the pair-wise comparisons are arranged in a matrix. The first (dominant) normalized right even vector of the matrix gives the ratio scale (weighting). The Eigen value determines the consistency ratio (Goepel, 2019).

3.8 How AHP Works

Thomas L. Saaty (2008), designed the AHP to make decisions in an organized way to generate the priorities needed to obtain a rational solution to a problem based on the following steps:

1. Define the problem and determine the kind of knowledge sought.
2. Structure the decision hierarchy with the decision goal at the top, then, examine the objectives from a broad perspective, from the beginning on through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually results in a set of the alternatives).
3. Construct a set of pairwise comparison matrices. Each element in an upper level is compared with the elements in the level immediately below it.
4. Use the priorities obtained from the comparisons to weigh the level priorities immediately. Do this for every element. Then, each element in the level below adds its weighed values and obtains its overall or global priority. Continue this process of weighing and adding until the final priorities of the alternatives in the bottom most level are obtained.

3.9 Features of AHP

The AHP is a very flexible and powerful tool because the scores and final ranking are obtained based on the pairwise relative evaluations of both the criteria and the options provided by the user. The computations made by AHP are always guided by the decision maker's experience, and AHP can thus be considered as a tool that is able to translate the evaluations (both qualitative and quantitative) made by the decision-maker into a multi-criteria ranking. In addition, the AHP is simple because there is no need to build a complex expert system since the AHP levels have the decision maker's knowledge embedded in them (Saaty,2008).

On the other hand, the AHP may require many evaluations by the user, especially for cases with many options and criteria. Even though every single evaluation is very simple, the load of the evaluation task may become unreasonable since it only requires the decision-maker to express how two options or criteria compare to each other. In fact, the number of pairwise comparisons grows quadratically with the number of criteria and options. For instance, when comparing 10 alternatives on four criteria, $4 \cdot 3/2=6$ comparisons are requested to build the weight vector, thus, $4 \cdot (10 \cdot 9/2) =180$ pairwise comparisons are needed to build the score matrix.

However, in order to reduce the decision maker's workload, the AHP can be completely or partially automated by specifying suitable thresholds for automatically deciding some pairwise comparisons (Saaty,2008).

3.10 Implementation of AHP

The AHP can be implemented in three simple consecutive steps:

1. Computing the vector of criteria weights
2. Computing the matrix of option scores
3. Ranking the options

3.11 AHP Programs

Different web-based AHP solutions have been developed as a supporting tool for several decision-making processes. These programs not only help the user meet daily work needs for simple decision problems, but it also supports complex decision-making problems. Internationally, AHP is used in a wide range of applications. For example, to evaluate suppliers in project management, in the hiring process, or in the evaluation of company performance, different AHP programs are available to supplement project management as shown in Table 3.9 where the function of each solution is given as it relates

to the given problem. In this research methodology, AHP Priority and IMPI analysis will be used to do the resraech analysis according to the data form the research survey.

Table 3.9 AHP Programs

NO.	Program	Function
1.	AHP Projects (AHP-OS)	Handle complete AHP projects including group decision support
2.	AHP Priority Calculator	Calculate priorities based on pairwise comparisons
3.	AHP Hierarchies	Define complete hierarchies; then, evaluate priorities and alternatives
4.	AHP Group Session	Participate in AHP group sessions.

3.12 AHP Structure

To facilitate understanding of the AHP process, figure 3.2 presents a simple diagram showing the steps of the research process with five levels. Comparisons were made on each level, and the results were combined to give a total picture of the construction material shortage problem. Figure 3.2 concisely labels each step and level.

Figure 3.2 Five-level AHP Structure Used to Evaluate Construction Material Shortages and Related Problems in Iraq.

3.13 AHP Calculations

The AHP software calculator was used to calculate income priority. A simple review follows showing how the calculations were run according to AHP income data.

The calculations were completed on three levels based on the comparison table below, which shows the income data based on the problems presented pertaining to problems presented in this thesis.

Table 3.10 Explanation of the Relation Between Data

Value of j, k	Interpretation
1	j and k are equally important
3	j is slightly more important than k
5	j is more important than k
7	j is strongly more important than k
9	j is absolutely more important than k

Where, J and K are the income data that need to be compared. In the first steps of calculation, the vector of criteria weights are computed using the following equations (Saaty, 2008).

$$\boldsymbol{a} = \frac{\boldsymbol{ajk}}{\sum_{\boldsymbol{i-1}}^{\boldsymbol{amk}} \boldsymbol{lk}}$$ .....Equation 3.1 and $$wj_{\sum_{i-a}^{m} \frac{ajl}{m}}$$ .....Equation 3.2

Where, M is the matrix to be created, aj and ak are the income data, a is the derivate matrix and W is the vector weight.

The second steps of the calculations are given to compute the matrix of option scores (Saaty, 2008)

S = [*s (1)* ... *s(m)]* ..... Equation 3.3

Where, s: score of evaluated options, S: score matrix, I, J: matrix criteria. The last step of the calculation's steps consists of ranking the options using the following equation (Saaty 2008).

v = S · w ..... Equation 3.4

Where v is the vector of the global scores, S is the score matrix, and w is the vector weight. This is a simple explanation of how the calculations were set up throughout the

project using the AHP software, which is easy to use and does not need high experience. Simply enter the number of factors in the required problem; then, enter each factor to establish the comparison by choosing the ranking number with each problem. According to the entries, the evaluation results will be achieved.

In this study case, the first comparison evaluated the material shortage weight as it related to the delay factors. The second step was evaluating each reason in the given category. The third step was to compare the important reasons for each category. This enabled us to see the impact of each reason on the shortage of construction material.

3.13 Summary

This chapter explained the methodology which was applied in this research. It describes and discusses the process of developing the questionnaire, as well as the AHP and actual survey. The methods used for analyzing the collected data included descriptive analysis, factor analysis and priority comparisons ranked to provide factor weights and evaluate the reasons behind those assigned weights. A great appreciation goes to all the survey participants. Without their contributions, this thesis could not be completed.

Chapter 4 Field Work Survey and Data Analysis

4.1 Introduction

This chapter discusses the analysis of results from the field survey that was conducted in Iraq from different respondents of five different groups: Consultants, Contractors, Project Managers, Project Engineers and Academic Experts in Iraq.

A total sample size of 50 respondents was selected for this survey. All 50 respondents participated in the field survey and gave their opinions regarding the impact of material shortages on the delay of projects in Iraq, which helped in the evaluation of the main problems leading to material shortages based on the questionnaire.

Primarily had five different parts. Part 1 gave respondents an opportunity to evaluate the weight of the material shortage factor compared to other delay factors. Part 2 contained questions regarding technical problems that can lead to material shortages. Part 3 provided questions on experience problems that can lead to material shortages. Part 4 provided questions on management problems that can lead to material shortages. Part 5 provided questions on government law problems that can lead to shortages in material. The chapter also discusses analysis techniques and the priority of results according to the AHP technique.

This chapter analyzes the calculations that were made using AHP (Analytic Hierarchy Process) priority software and the IMPI (Importance Index Method). The chapter uses tables, pie charts and graphs to represent statistical data of the information that was collected from the respondents.

4. 2 Respondents Demography

Demography involves sample size, gender, sector, designations and details of the respondents that were part of the field survey.

Table 4.1 shows the sample size (number sent) and number of respondents that received surveys. Fifty respondents participated to the questionnaire, and all the respondent participated throughout the survey development and processing because preparation and efforts to connect with participants continued until the end of the survey, participant cooperation was a great help. We also attempted to answer any questions or concerns from respondents, and we made sure the respondents were comfortable with the questions. We also remained open to any ideas or advice the respondents gave.

Table 4.1 Respondent Categories

Position	Sector	Number Sent	Number Responded
Project Engineer	Public	7	7
	Private	4	4
Project Manager	Public	6	6
	Private	8	8
Contractor	Private	12	12
Consultant	Public	3	3
	Private	4	4
Academic Expert	Public	3	3
	Private	3	3

. Table 4.2 shows the respondents gender and figure 4.1 provides a pie chart breaking down the percentages of gender participation in the survey.

Table 4.2 Respondent Gender

Male	38
Female	12
Total	50

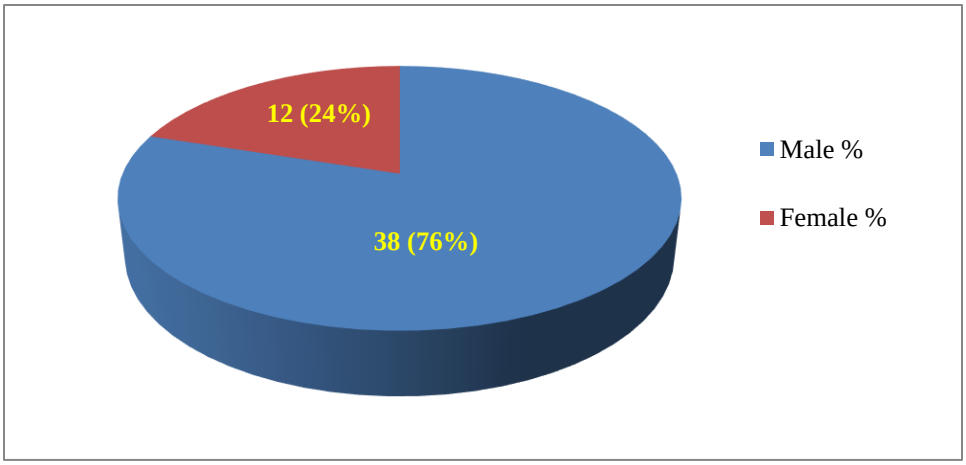


Figure 4.1 Number of Respondents and Participation Percentage Based on Gender

4.3 Survey Level 1 Results

Table 4.3 below will show survey results for the impact of each factors on delay according to the participants choices using AHP method. And table 4.4 will show the test results according to IMPI method.

Table 4.3 Delay Factors Survey Results

No.	Delay Factors	S. Less Important	Less Important	Important	More Important	S. More Important
1.	Unrealistic contract duration	2	3	19	21	5
2.	Scope of the project was not well defined	1	4	19	7	7
3.	Poor contract management	0	0	24	15	11
4.	Inadequate early planning of the project	15	20	8	7	0
5.	Inadequate early scheduling of the project	10	25	10	3	2
6.	Late in approving design documents by owner	4	5	27	6	8
7.	Suspension of work	2	1	20	10	17
8.	Delay in progress payment by owner	0	2	15	10	23
9.	Poor communication between owner and other parties	5	7	12	15	11
10.	Poor site management	0	1	12	20	17

Table 4.3 Continued

No.	Delay Factors	S. Less Important	Less Important	Important	More Important	S. More Important
11.	Poor qualification of contractor's staff assigned to the project	6	3	11	13	17
12.	Shortage of material	0	0	8	12	30
13.	Delay in equipment delivery	3	4	12	20	11
14.	Delay in obtaining permits from municipality	10	12	10	8	10
15.	Effect of weather	2	1	17	7	23
16.	Effect of weather	2	1	17	7	23
17.	Project traffic control	24	10	7	5	4
18.	Political security issues	7	9	15	9	10
19.	Economic stability issues	7	12	19	8	4
20.	Changes in government regulations and laws	9	12	10	14	5

Table 4.4 First Questionnaire-Level Results for Weight of Material Shortage Factor Due to Delay Using IMPI

No.	Delay Factors	S. Less Important a1	Less Important a2	Important a3	More Important a4	S. More Important a5
1.	Unrealistic contract duration	2	3	19	21	5
2.	Scope of the project was not well defined	1	4	19	7	7
3.	Poor contract management	0	0	24	15	11
4.	Inadequate early planning of the project	15	20	8	7	0
5.	Inadequate early scheduling of the project	10	25	10	3	2
6.	Late in approving design documents by owner	4	5	27	6	8
7.	Suspension of work	2	1	20	10	17
8.	Delay in progress payment by owner	0	2	15	10	23
9.	Poor communication between owner and other parties	5	7	12	15	11
10.	Poor site management	0	1	12	20	17

Table 4.4 Continued

No.	Delay Factors	S. Less Important a1	Less Important a2	Important a3	More Important a4	S. More Important a5
11.	Poor qualification of contractor's staff assigned to the project	6	3	11	13	17
12.	Shortage of material	0	0	8	12	30
13.	Delay in equipment delivery	3	4	12	20	11
14.	Delay in obtaining permits from municipality	10	12	10	8	10
15.	Effect of weather	2	1	17	7	23
16.	Effect of weather	2	1	17	7	23
17.	Project traffic control	24	10	7	5	4
18.	Political security issues	7	9	15	9	10
19.	Economic stability issues	7	12	19	8	4
20.	Changes in government regulations and laws	9	12	10	14	5

Thanks to the 100% participation of the 50 survey respondents, I valuable results were achieved especially since all the participant were experts within the construction industry. Table 4.3 and table 4.4 presents the results for each level of the questionnaire, which are structured into groups based on the AHP priority method and IMPI method.

4.3.1 Survey Level 1 Importance Consideration for AHP Test

As previously mentioned in this thesis, the factors used in the survey are all important. However, their impact varies when assessing project delay. For the final analysis we will use the "significantly more important" criteria to categorize the differences in each of the factor groups, we set up eight levels of Importance to ensure their eligibility as criteria for priority analysis. Table 4.5 shows the Importance criteria according to the difference between the eight factor groups.

Table 4.5 Factor Differences Category

Group Number Importance	Difference Between Factors
2	1-5
3	6-10
4	11-15
5	16-20
6	21-25
7	26-30
8	31-35
9	36-40

4.4 Evaluating the Weight of Shortage of Material Using AHP

As noted throughout this research, AHP priority software was used to achieve and evaluate the weight of material shortages and compare it to other delay factors. The following steps explains the software process used to achieve our required goal.

1. Click AHP to start pairwise comparisons and to find the weight (importance) of criteria.
2. Enter each criterion in the entry data field and insert the number of criteria you have to compare.
3. The software will start comparing each pair of criteria with respect to the project and category according to which criterion in each pair is more important and how much more on a 1 - 9 scale (based on how we grouped our results to analyze the differences).
4. After completing data entry, select “Group Results.” The results and diagrams will appear and can be saved for future use.
5. From the “Group Result” menu, it is possible to use the calculated priorities of the decision hierarchy for further alternative evaluations.
6. You can download the data in csv format (comma separated values) for further processing in a spread sheet program.

This is a simple explanation on how the AHP priority software works, the software is available online at: https://bpmsg.com/ahp/ahp-calc.php. It is easy to use and does not need advanced high-level experience to use. For that reason, many organizations use AHP software because it does not require professional training to use.

4.5 Test Results for Weight of Material Shortages

4.5.1 AHP-Priorities

Table 4.6 shows the resulting weights for the criteria based on pairwise comparisons. And figure 4.2 will explain the results in chart way.

Table 4.6 AHP Test Comparison Results

No.	Delay Factors	Priority	Rank	(+)	(-)
1.	Unrealistic contract duration	2.2%	15	1.3%	1.3%
2.	Project scope is not well defined	2.7%	14	1.1%	1.1%
3.	Poor contract management	3.8%	9	1.5%	1.5%
4.	Inadequate early planning of project	1.1%	20	0.4%	0.4%
5.	Inadequate early scheduling of project	1.3%	19	0.4%	0.4%
6.	Late in approving design documents by owner	3.7%	10	1.9%	1.9%
7.	Suspension of work	7.7%	4	3.7%	3.7%
8.	Delay in progress payment by owner	9.7%	3	4.5%	4.5%
9.	Poor communication between owner and other parties	3.6%	11	1.3%	1.3%
10.	Poor site management	6.6%	5	2.7%	2.7%
11.	Poor qualification of contractor's staff assigned to the project	6.4%	6	2.9%	2.9%
12.	Shortage of material	19.1%	1	11.4 %	11.4 %
13.	Delay in equipment delivery	5.0%	7	5.2%	5.2%
14.	Delay in obtaining city permits	3.0%	12	1.3%	1.3%
15.	Effect of weather	10.9%	2	4.8%	4.8%
16.	Project traffic control issues	2.0%	16	1.9%	1.9%
17.	Political security issues	3.0%	13	1.4%	1.4%
18.	Economic stability issues	1.6%	18	0.5%	0.5%
19.	Changes in government regulations and laws	1.9%	17	0.7%	0.7%
20.	Effects of subsurface conditions	4.7%	8	1.8%	1.8%

Number of comparisons = 190 Consistency Ratio CR = 6.7%

4.5.2 Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix and Table 4.7 shows the analytic decision matrix

Table 4.7 The Decision Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	0.50	0.33	2.00	2.00	0.50	0.25	0.20	0.33	0.25	1.00	0.17	0.50	1.00	0.20	1.00	2.00	1.00	1.00	0.33
2	2.00	1	0.50	3.00	2.00	0.50	0.33	0.20	1.00	1.00	0.50	0.17	0.50	0.50	0.20	2.00	0.50	2.00	2.00	0.50
3	3.00	2.00	1	4.00	3.00	2.00	0.33	0.25	1.00	0.33	0.33	0.20	1.00	2.00	0.33	3.00	2.00	3.00	1.00	0.50
4	0.50	0.33	0.25	1	0.50	0.33	0.20	0.17	0.25	0.20	0.20	0.14	0.25	0.33	0.17	0.50	0.33	0.50	0.50	0.25
5	0.50	0.50	0.33	2.00	1	0.33	0.25	0.17	0.33	0.25	0.25	0.14	0.33	0.33	0.17	0.50	0.33	0.50	0.50	0.33
6	2.00	2.00	0.50	3.00	3.00	1	1.00	1.00	1.00	1.00	1.00	0.17	0.50	0.50	0.25	2.00	0.50	2.00	2.00	0.50
7	4.00	3.00	3.00	5.00	4.00	1.00	1	0.33	3.00	1.00	3.00	0.25	3.00	3.00	0.50	4.00	3.00	4.00	4.00	3.00
8	5.00	5.00	4.00	6.00	6.00	1.00	3.00	1	4.00	2.00	1.00	0.33	0.33	4.00	1.00	5.00	4.00	5.00	5.00	4.00
9	3.00	1.00	1.00	4.00	3.00	1.00	0.33	0.25	1	0.33	0.33	0.20	1.00	2.00	0.25	3.00	2.00	3.00	3.00	0.50
10	4.00	1.00	3.00	5.00	4.00	1.00	1.00	0.50	3.00	1	1.00	0.25	3.00	3.00	0.33	4.00	3.00	4.00	4.00	2.00
11	1.00	2.00	3.00	5.00	4.00	1.00	0.33	1.00	3.00	1.00	1	0.25	3.00	3.00	0.33	4.00	3.00	4.00	4.00	2.00
12	6.00	6.00	5.00	7.00	7.00	6.00	4.00	3.00	5.00	4.00	4.00	1	6.00	5.00	6.00	7.00	5.00	7.00	6.00	5.00
13	2.00	2.00	1.00	4.00	3.00	2.00	0.33	3.00	1.00	0.33	0.33	0.17	1	2.00	0.25	3.00	2.00	3.00	3.00	0.50
14	1.00	2.00	0.50	3.00	3.00	2.00	0.33	0.25	0.50	0.33	0.33	0.20	0.50	1	0.25	3.00	1.00	3.00	2.00	0.50
15	5.00	5.00	3.00	6.00	6.00	4.00	2.00	1.00	4.00	3.00	3.00	0.17	4.00	4.00	1	1.00	5.00	4.00	5.00	4.00
16	1.00	0.50	0.33	2.00	2.00	0.50	0.25	0.20	0.33	0.25	0.25	0.14	0.33	0.33	1.00	1	0.33	1.00	0.50	0.33
17	0.50	2.00	0.50	3.00	3.00	2.00	0.33	0.25	0.50	0.33	0.33	0.20	0.50	1.00	0.20	3.00	1	3.00	2.00	0.50
18	1.00	0.50	0.33	2.00	2.00	0.50	0.25	0.20	0.33	0.25	0.25	0.14	0.33	0.33	0.25	1.00	0.33	1	0.50	0.33
19	1.00	0.50	1.00	2.00	2.00	0.50	0.25	0.20	0.33	0.25	0.25	0.17	0.33	0.50	0.20	2.00	0.50	2.00	1	0.33
20	3.00	2.00	2.00	4.00	3.00	2.00	0.33	0.25	2.00	0.50	0.50	0.20	2.00	2.00	0.25	3.00	2.00	3.00	3.00	1

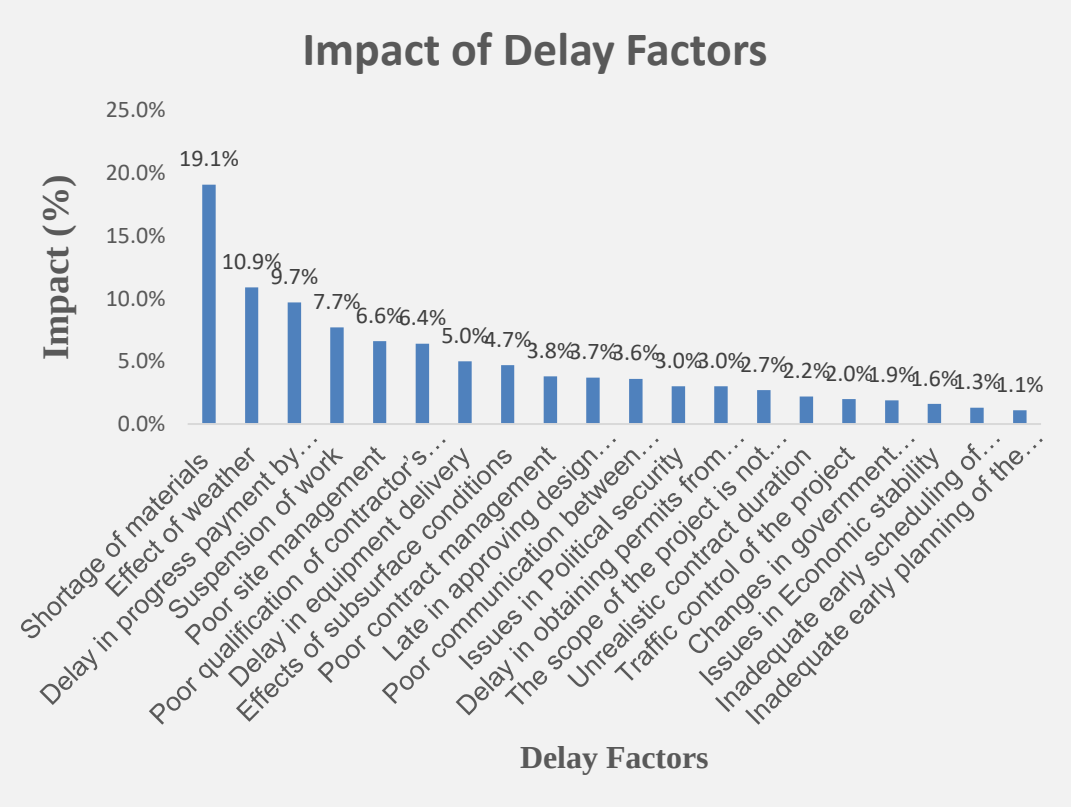


Figure 4.2 Delay Factors in AHP Test Result

4.5.3 IMPI Statistical Analysis Test Results

Table 4.8 shows the resulting for the importance of factors according to the IMPI method. And figure 4.3 will explain the results in chart way.

Table 4.8 IMPI Statistical Analysis Test Results

NO.	Delay Factors	a1	a2	a3	a4	a5	F.I.	S.I.	F.I.*S.I.
1.	Unrealistic contract duration	2	3	19	21	5	69.6	69.6	48
2.	The scope of the project is not well defined	1	4	19	7	7	51.6	69.6	36
3.	Poor contract management	0	0	24	15	11	74.8	69.6	52
4.	Inadequate early planning of the project	15	20	8	7	0	42.8	69.6	30

Table 4.8 Continued

NO.	Delay Factors	a1	a2	a3	a4	a5	F.I.	S.I.	F.I.*S.I.
5.	Inadequate early scheduling of the project.	10	25	10	3	2	44.8	69.6	31
6.	Late in approving design documents by owner.	4	5	27	6	8	63.6	69.6	44
7.	Suspension of work.	2	1	20	10	17	75.6	69.6	53
8.	Delay in progress payment by owner.	0	2	15	10	23	81.6	69.6	57
9.	Poor communication between owner and other parties.	5	7	12	15	11	68	69.6	47
10.	Poor site management.	0	1	12	20	17	81.2	69.6	57
11.	Poor qualification of contractor's staff assigned to the project.	6	3	11	13	17	72.8	69.6	51
12.	Shortage of material.	0	0	8	12	30	88.8	69.6	62
13.	Delay in equipment delivery.	3	4	12	20	11	72.8	69.6	51
14.	Delay in obtaining permits from Municipality.	10	12	10	8	10	58.4	69.6	41
15.	Effect of weather.	2	1	17	7	23	79.2	69.6	55
17	Traffic control of the project.	24	10	7	5	4	42	69.6	29
18	Issues in Political security.	7	9	15	9	10	62.4	69.6	43
19	Issues in Economic stability.	7	12	19	8	4	56	69.6	39
20	Changes in government regulations and laws.	9	12	10	14	5	57.6	69.6	40

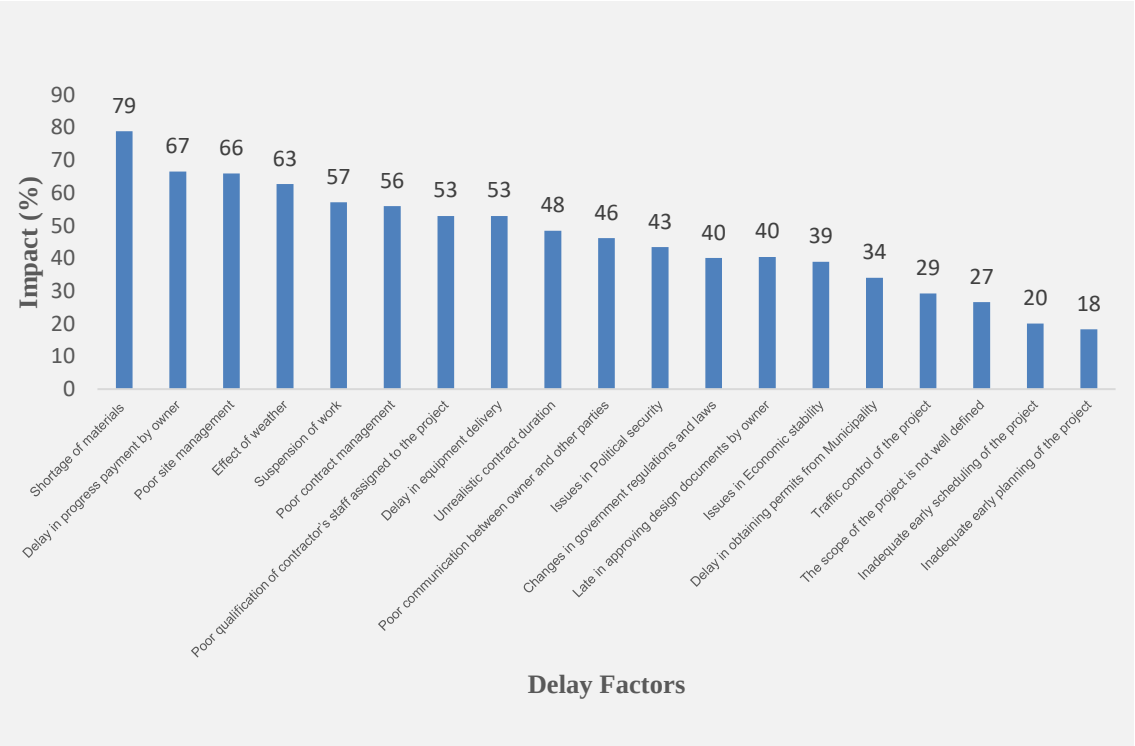


Figure 4.3 Delay Factors in IMPI Statistical Analysis

4.6 Shortage of Material Problems Survey

As we mentioned in Chapter 3, the second part of the survey was used to evaluate the problems leading to a shortage of material, and the problems were categorized in four main categories: technical, experience, government laws and management problems. In each category major problems had to be evaluated to find the most effective problem in each category. The same process from the first part of the survey will be followed, and the same software will be used, i.e., AHP priority software. Table 4.9 shows the results for the technical cause leading to shortage of material questionnaire, and these results will be structured in groups to be eligible for the AHP priority method. The same group criteria were used at the first part of the survey.

Table 4.9 Survey Results for Technical Problems Leading to Material Shortages

NO	Technical Problems	S. Less Important	Less Important	Important	More Important	S. More Important
1.	Lack of accuracy in test data specifications for construction material at the customs location.	7	15	7	6	15
2.	Lack of accurate code requirement so the construction material could pass customs.	1	4	13	14	18
3.	No experienced employee who could understand the requirement of the customs' code.	0	0	11	15	24

4.6.1 Survey Level 2 Importance Consideration

As previously mentioned, the research problems used in the survey were set up to identify the main problems; thus, all of them are important, but the impacts varied depending on types and circumstances behind the material shortages. Analyzing the causes and effects of these impacts was achieved by using the "significantly more Important" choice as the major point of analysis criteria. We categorized the differences between the factors' importance into eight levels of Importance to determine their eligibility for priority analysis.

The importance criteria according to the differences between factors are shown in table 4.9, and figure 4.4 will explain the results in chart way.

Table 4.10 Factors Differences Category

Importance Group Number	Difference Between the Factors
2	1-5
3	6-10
4	11-15
5	16-20
6	21-25
7	26-30
8	31-35
9	36-40

4.6.2 Evaluate the Weight of Material Shortages

As previously mentioned, AHP priority software was used to achieve and evaluate the worst technical problems, which can cause a shortage of material.

4.7 AHP Test Technical Problems Results

4.7.1 Priorities

Table 4.11 shows the resulting weights for the criteria based on pairwise comparisons. And figure 4.4 will explain the results as chart view.

Table 4.11 Technical Problems by AHP Test Comparison Results

No.	Technical Problems	Priority	Rank	(+)	(-)
1.	Lack of accuracy and test data specifications for construction material at the customs location.	13.7%	3	1.8%	1.8%
2.	Lack of accurate code requirements for the construction material to follow at the customs.	23.8%	2	3.2%	3.2%
3.	No experienced employee who understands the code requirements at customs.	62.5%	1	8.4%	8.4%

Number of comparisons = 3 Consistency Ratio CR = 1.9%

4.7.2 Decision Matrix

The resulting weights are based on the principal Eigen vector of the decision matrix as explained in table 4.12.

Table 4.12 Decision Matrix

	1	2	3
1	1	0.50	0.25
2	2.00	1	0.33
3	4.00	3.00	1

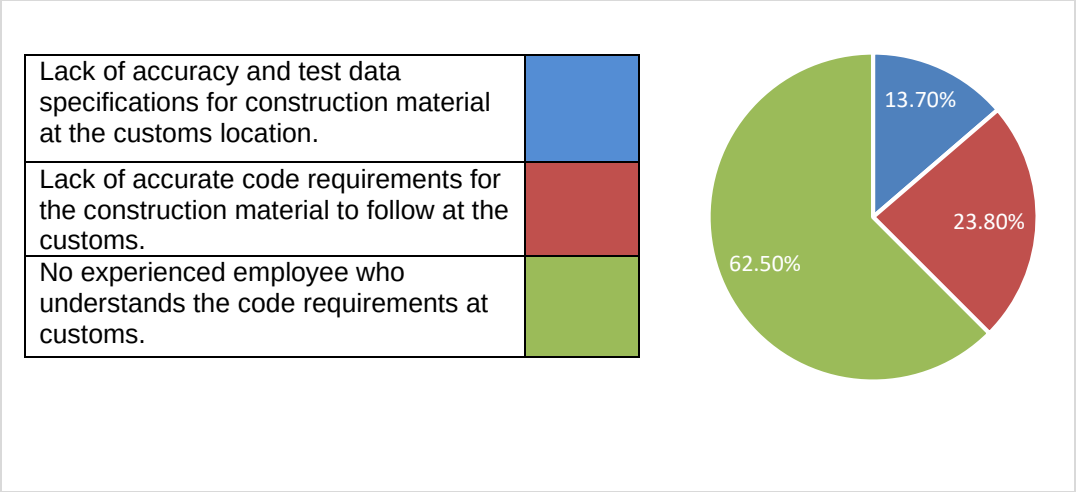


Figure 4.4 Technical Problems Based on AHP Test Result Chart

4.8 Survey Results for Experience Problems Leading to Shortage of Material

Table 4.13 lists the survey results for the experience problems leading to material shortages.

Table 4.13 Survey Results for Experience Problems Leading to Material Shortages

No.	Experience problems	S. Less Important	Less Important	Important	More Important	S. More Important
1.	Lack of control the bad quality and cheap material in the market.	2	1	12	14	21
2.	Lack of experience manage or supervised at the production plant.	1	4	16	12	17
3.	Lack of experience owners or investors to run the existing material factories.	0	1	12	9	28
4.	Lack of experienced consultant and estimator to estimate the need of material for the project.	5	8	8	12	17
5.	Lack of experienced person to control construction material on site.	4	2	15	13	16
6.	No consultant knowledge on the availability of material on market.	4	5	17	6	18

4.9 AHP Test Experience Problems Results

4.9.1 Priorities

Table 4.14 will show the resulting weights for the criteria based on the pairwise comparisons, and figure 4.5 will explain the results in chart way.

Table 4.14 Experience Problems by AHP Test Comparison Results

No.	Experience Problems	Priority	Rank	(+)	(-)
1	Lack of control on bad quality and cheap material in the market.	18.6%	2	5.6%	5.6%
2	Lack of experience to manage or supervise at the production plant.	9.8%	4	2.2%	2.2%
3	Lack of experience of owners or investors to run existing material factories.	40.0%	1	8.7%	8.7%
4	Lack of experienced consultant and estimator to estimate the need of the material for the project.	9.8%	4	2.2%	2.2%
5	Lack of experienced person to control the construction material on site.	7.1%	6	2.1%	2.1%
6	Lack of consultant knowledge on the availability of the material in the market.	14.7%	3	3.9%	3.9%

Number of comparisons = 15 Consistency Ratio CR = 2.6

4.9.2 Decision Matrix

The resulting weights are based on the principal Eigen vector of the decision matrix as explained in table 4.15.

Table 4.15 Decision Matrix

	1	2	3	4	5	6
1	1	2.00	0.33	2.00	2.00	2.00
2	0.50	1	0.25	1.00	2.00	0.50
3	3.00	4.00	1	4.00	4.00	3.00
4	0.50	1.00	0.25	1	2.00	0.50
5	0.50	0.50	0.25	0.50	1	0.50
6	0.50	2.00	0.33	2.00	2.00	1

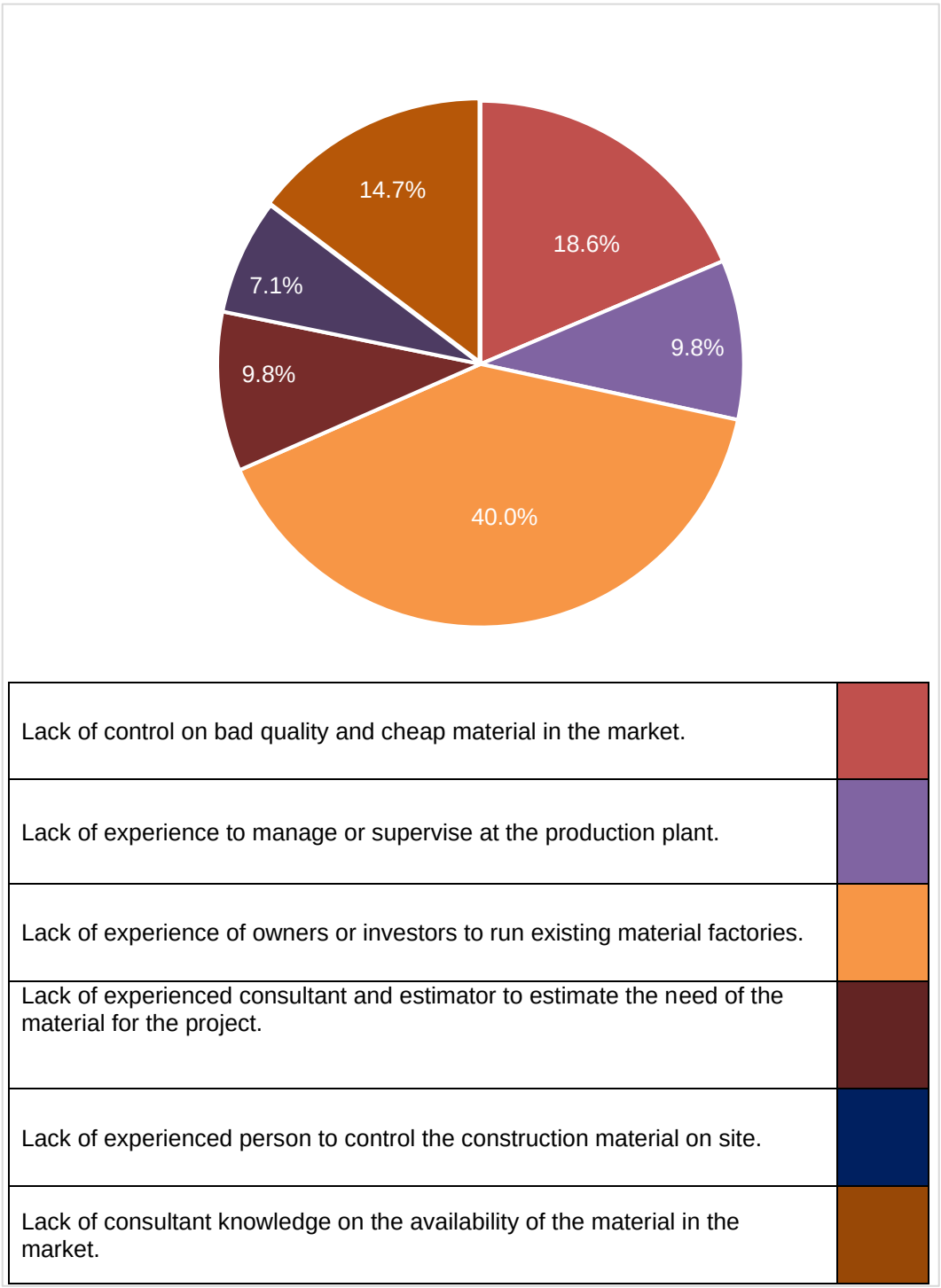


Figure 4.5 Experience Problems Based on AHP Test Result Chart

4.10 Survey Result for Management Problems That Leading to Shortage of Material

Table 4.16 lists the survey results for the lack-of-experience problem, which leads to the shortage of material.

Table 4.16 Survey Results for Management Problems Leading to Material Shortages

No.	Management Problems	S. Less Important	Less Important	Important	More Important	S. More Important
1.	Lack of options on construction material sources.	2	3	19	10	16
2.	Lack of updated codes according to the market.	1	4	8	7	18
3.	Lack of material managing system in projects.	0	0	11	11	28
4.	Lack of updated inventory and the need of material during project progress.	4	2	12	12	20
5.	Lack of proper plan to store the material.	5	6	10	10	19
6.	Lack of proper storage for project material.	4	5	12	7	22
7.	Lack of communication between the contractors and the consultants to update the material availability.	2	1	12	10	25

4.11 AHP Test Management Problems Results

4.11.1 Priorities

Table 4.17 compares the resulting weights for the criteria based on pairwise comparisons, and figure 4.6 will explain the results in chart way.

Table 4.17 Management Problems by AHP Test Comparison Results

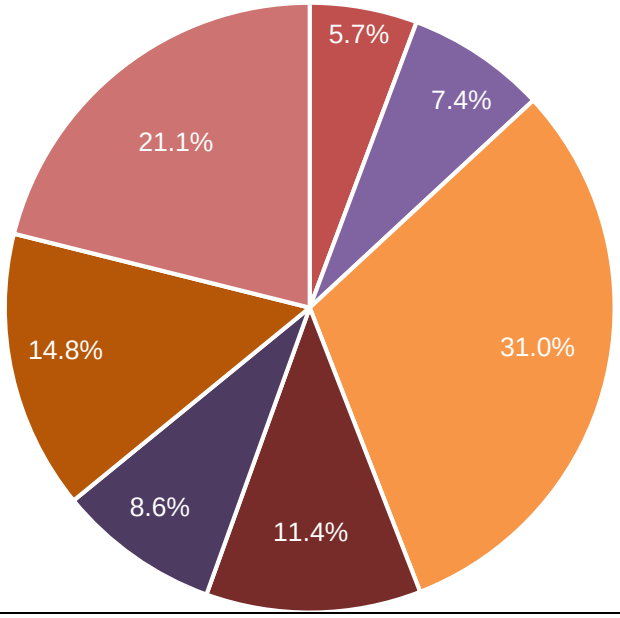
No.	Management Problems	Priority	Rank	(+)	(-)
1	Lack of options for sources of the construction material.	5.7%	7	2.1%	2.1%
2	Lack of updates of codes according to the market.	7.4%	6	2.4%	2.4%
3	Lack of material managing system in the project.	31.0%	1	9.5%	9.5%
4	Lack of updated inventory and the need of material during the project progress.	11.4%	4	3.1%	3.1%
5	Lack of proper plan to store the material.	8.6%	5	3.0%	3.0%
6	Lack of proper storage for material in the project.	14.8%	3	4.1%	4.1%
7	Lack of communication between the contractors and the consultants to update the material availability.	21.1%	2	8.1%	8.1%

4.11.2 Decision Matrix

The resulting weights are based on the principal Eigen vector of the decision matrix as explained in table 4.18.

Table 4.18 Decision Matrix

	1	2	3	4	5	6	7
1	1	0.50	0.33	0.50	0.50	0.33	0.33
2	2.00	1	0.33	0.50	0.50	0.50	0.33
3	3.00	3.00	1	3.00	4.00	3.00	2.00
4	2.00	2.00	0.33	1	2.00	0.50	0.50
5	2.00	2.00	0.25	0.50	1	0.50	0.33
6	3.00	2.00	0.33	2.00	2.00	1	0.50
7	3.00	3.00	0.50	2.00	3.00	2.00	1



Lack of options for sources of the construction material.	
Lack of updates of codes according to the market.	
Lack of material managing system in the project.	
Lack of updated inventory and the need of material during the project progress.	
Lack of proper plan to store the material.	
Lack of proper storage for material in the project.	
Lack of communication between the contractors and the consultants to update the material availability.	

figure 4.6 Management Problems Based on AHP Test Results Chart

4.12 Survey Results for Government Law Problems

Leading to Shortage of Material

Table 4.19 show the survey results for the government law problems, which leading to a shortage of material.

Table 4.19 Survey Results for Government Laws Problem Leading to Material Shortages

No.	Government Laws Problems	S. Less Important	Less Important	Important	More Important	S. More Important
1.	No limitations on specific brands and manufacturers for the import of construction material.	4	5	12	10	19
2.	Lack of government laws on the marketing of construction material.	3	4	12	13	18
3.	Lack of the government laws on the specifications of imported construction material.	0	0	15	12	23
4.	Unstable government code requirements for material.	5	8	7	10	20
5.	Different requirements for construction material specifications in each government location.	10	4	10	8	18
6.	Continuous changes to the specification from the government for each project.	4	3	10	13	20
7.	Shutdown of local plants for material production.	2	1	12	10	25
8.	The corruption which prevents the production to make profit from imports.	0	2	15	10	23
9.	Lack of government support to run private material factories.	4	3	11	10	22
10.	Lack of government plans to run public factories.	3	2	12	13	20
11.	Lack of government plans to build and develop new factories.	3	3	14	11	19

4.13 AHP Test Government Laws Problems Results

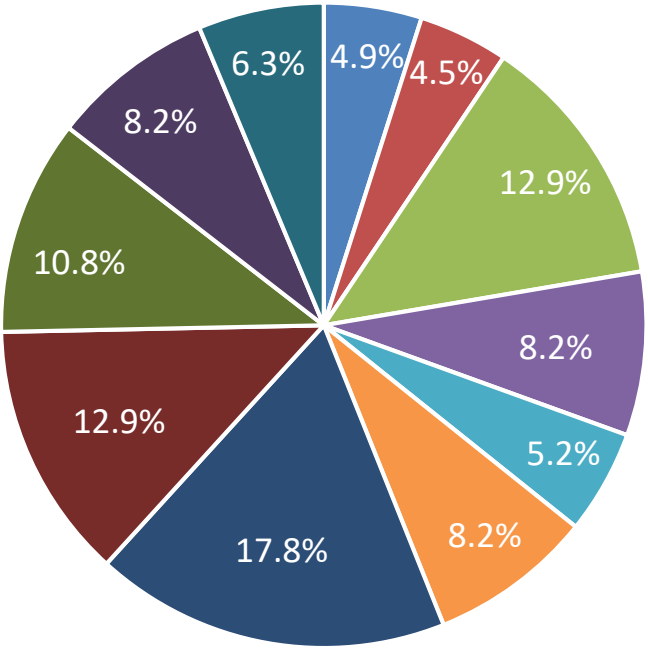
4.13.1 Priorities

Table 4.20 lists the resulting weights for the criteria based on your pairwise comparisons, and figure 4.7 will explain the results in chart way.

Table 4.20 Government Laws Problems by AHP Test Comparison Results

No.	Government Laws Problems	Priority	Rank	(+)	(-)
1	No limitations on specific brands and their manufacturer for the import of construction material.	4.9%	10	1.8%	1.8%
2	Lack of the government laws on marketing of construction material.	4.5%	11	1.3%	1.3%
3	Lack of government legal guidance regarding specifications of imported construction material.	12.9%	2	3.8%	3.8%
4	Unstable government code requirements for material.	8.2%	5	1.9%	1.9%
5	Different requirements construction material specifications at each government location.	5.2%	9	1.8%	1.8%
6	Continuous changes of specifications from the government for each project.	8.2%	5	1.9%	1.9%
7	Shutdown of local plants for material production	17.8%	1	4.0%	4.0%
8	The corruption which prevents the production to make profit from the import	12.9%	2	3.8%	3.8%
9	Lack of government support to run the private material factories	10.8%	4	3.6%	3.6%
10	Lack of government plans to run the public factories.	8.2%	5	1.9%	1.9%
11	Lack of government plans to build and develop new factories	6.3%	8	2.2%	2.2%

Number of comparisons = 55 Consistency Ratio CR = 2.8%



No limitations on specific brands and their manufacturer for the import of construction material.	
Lack of the government laws on marketing of construction material.	
Lack of government legal guidance regarding specifications of imported construction material.	
Unstable government code requirements for material.	
Different requirements construction material specifications at each government location.	
Continuous changes of specifications from the government for each project.	
Shutdown of local plants for material production	
The corruption which prevents the production to make profit from the import	
Lack of government support to run the private material factories	
Lack of government plans to run the public factories.	
Lack of government plans to build and develop new factories	

Figure 4.7 Government Laws Problems Based on AHP Test Results Chart

4.13.2 Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix as explained in table 4.21.

Table 4.21 Decision Matrix

	1	2	3	4	5	6	7	8	9	10	11
1	1	2.00	0.50	0.50	0.50	0.50	0.33	0.50	0.50	0.50	0.50
2	0.50	1	0.50	0.50	1.00	0.50	0.33	0.50	0.50	0.50	0.50
3	2.00	2.00	1	2.00	2.00	2.00	0.50	1.00	2.00	2.00	2.00
4	2.00	2.00	0.50	1	2.00	1.00	0.50	0.50	0.50	1.00	2.00
5	2.00	1.00	0.50	0.50	1	0.50	0.33	0.50	0.50	0.50	0.50
6	2.00	2.00	0.50	1.00	2.00	1	0.50	0.50	0.50	1.00	2.00
7	3.00	3.00	2.00	2.00	3.00	2.00	1	2.00	2.00	2.00	3.00
8	2.00	2.00	1.00	2.00	2.00	2.00	0.50	1	2.00	2.00	2.00
9	2.00	2.00	0.50	2.00	2.00	2.00	0.50	0.50	1	2.00	2.00
10	2.00	2.00	0.50	1.00	2.00	1.00	0.50	0.50	0.50	1	2.00
11	2.00	2.00	0.50	0.50	2.00	0.50	0.33	0.50	0.50	0.50	1

4.14 Important Factors Identified from Survey Part 1

Important factors were identified from the testing of given factors. According to survey respondents and the AHP test for the responding data, we evaluated the weight of the shortage of material as one factor related to other delay factors. From the total of 100%, the shortage of material effect was 19.1%, which is huge, followed by weather delays and payment tardiness by the owner.

This number means delays because material shortages is a common delay and is well known, especially since most of the respondents were experts, who were still working in the construction field. The problem in the Iraq construction industry is that any delay due

to shortage of material can cause a suspension of the project, which adversely affect all the activities on project. Suspension is often more than a short-term problem. Sometimes it takes months before the project can start again.

4.15 Important Factors Identified from Survey Part 2

The absence of an experienced employee who is trained in code requirements at the customs office was the major technical problem leading to a 62.5% shortage of material compared to other technical problems. The next problem is a lack of experienced owners or investors to run the existing material factories which accounted for 40% of the total loss when compared to other experience problems. Lack of a material managing system in the projects was the major management problem with 31% of total, while shutdown of local plants for material production was a major problem for the government category with 17% of that total.

Chapter 5 Conclusions and Recommendations for Future

5.1 Introduction

The first chapter summarized the research objectives, background and scope of this research followed by a literature review in Chapter 2, which supported statements defining the research problems. Chapter 3 discussed the research methodology, and Chapter 4 discussed the advantages of the Analytic Hierarchy Process (AHP) in evaluation. Survey results and comparisons were made verifying our research. This chapter provides conclusions and recommendations based on the research problem that has been identified and explored in this thesis.

This research sought to develop a structural evaluation based on the shortage of material and other factors of delay for the Iraq construction industry. Defining the most challenging problems or bottlenecks in the construction industry is the first step to meeting the needs of the construction industry in Iraq: The next task was to determine how material shortages affect construction progress. The construction experts who responded in full force to our survey (100% participation) helped define the material shortage problems, which is the first step to solving these problems in Iraq.

Consequently, this chapter presents and describes the overall achievements of this research based on the literature review and questionnaire survey. The author also presents the conclusions of this study which are in line with the objectives of the study as stated in Chapter 1. The limitations of the study are presented and recommendations for future work are given.

5.2 Conclusions

The two objectives of this study were achieved through the completion of this research. These objectives have been explained in detail throughout this study. The summary of all the findings follow:

5.2.1 Objective 1: Evaluate the Weight of Material Shortages Compared to Other Delay Factors

The first objective was to determine and evaluate the weight of material shortages compared to other delay factors. This objective was achieved through analyzing actual questionnaire survey data collected from 50 construction experts who are working or had previously worked in the Iraq construction industry.

This weight of material shortages problem compared with other problems was analyzed using the AHP priority test method using AHP software. The ranking analysis determined the rank and the impact of material shortages and the results are shown in Tables 4.3 and 4.6.

5.2.2 Objective 2: Categorize the Problems Leading to Material Shortages and Evaluate Them

The second objective was to categorize the problems that lead to material shortages into four main groups and then to evaluate each problem and compare it to the other problems in the same category. This objective was achieved through analyzing the collected data and analyzing the survey results through the AHP software. The findings revealed four categories*:* Technical problems, Experience problems, Management problems and Government Laws problems.

5.3 Limitations of the Study

This study has achieved the aim and objectives which were set out in Chapter 1; however, it has some limitations. These limitations are described below:

1. The respondents of this study were limited to project managers, project engineers, contractors, consultants and academic experts who were working at the time of the survey or had worked in the Iraq construction industry. All participants were

Iraqi construction experts with past on-the-job experiences in the construction industry.

2. Identification of the important delay factors were generated from previous studies. and were familiar to the experts who had dealt with delays throughout Iraq as part of their construction experience.
3. This study collected data using structured questionnaires with a data distribution that used research from 1995- 2018.
4. Findings of this study only apply to the Iraq construction industry. Thus, they can be very helpful to researchers focusing on solving construction problems in Iraq.

5.4 Recommendations for Future Research

Recommendations for future research based on this study described as follows:

1. The scope of this research is limited to the Iraq construction industry. However, further research should be carried out in each Iraqi city to find community and economy as well as other problems that may vary from city to city.
2. The findings of this study can be further investigated qualitatively by conducting case studies. It will be more beneficial for the construction industry to integrate the identified factors along the phases of a project's life cycle. This will help to determine the impact of material shortages on delay in Iraqi construction projects.
3. These findings can be further explored qualitatively by carrying out research to determine mitigation measures to control any construction delay by material shortages experienced in Iraq construction projects.
4. The Iraq construction Industry needs to develop a construction material management system and accurate data management control as well as monitoring the material in the construction project.

5. To develop real training and more experience, schools should conduct classes to explain the material shortages and to teach how to better control these shortages.
6. Establish real technical offices with professional engineers and technicians at custom to test and evaluate the requirement of imported material to make sure all orders follow the required codes.
7. Develop studies to define the role of investors or the owners of the construction material, which should be based on their experience and ability to run the factories; thus, the government should work toward eliminating corruption in factory investments so that only qualified operators can run factories..
8. Develop a system for government monitoring of the market to ensure compatibility of all construction material with building codes.
9. Develop a system for government with the help of official academic centers to issue real and permanent laws for handling construction material and to always keep the existing codes updated and compatible with the market.
10. Become familiar with management software and applications so as to always monitor the progress of the projects and to monitor the availability of the required material in the project inventory thereby providing continuous training and updating for management applications. Although this research was limited to the Iraq construction industry, the findings will most likely be applicable to construction projects implemented in any part of Iraq. Hopefully these findings will help the authority and construction players (contractor, consultants, owners, and clients) to minimize any potential delays in the construction industry.

Appendix A

Survey Form

University of Texas at Arlington
College of Engineering
Department of Civil Engineering

Research Survey

Impact Material Delays in Construction Projects in Iraq

Dr. Mohammad Najafi , Ph.D., P.E,
Omar Abdullah
Department of Civil Engineering
Master of Science graduate student
in civil engineering

To: **Whom it May Concern**
Date :Oct.10. 2019

Expert Opinion Survey for Impact material delays in construction projects in Iraq

1- Goal of the survey

According to our work to evaluate the impaction of shortage of the construction material on the projects delay and as part of this work, we are looking to find and evaluate the following :

1- the weight based on the likelihood of shortage of material that will the delay of projects.

2- the main reason, which led to the shortage of material.

The calculations will depend on the weight of each reason and final calculation. Analysis will be achieved using AHP (The Analytic Hierarchy Process) as the foundation of our analysis and recommendations.

According to our research and literature review, for the first part of the survey we chose 20 Important factors causing delay in Iraq construction industry from the literature review and According to the discussion with the expert in Iraq construction industry, and we used these factors to Evaluate the affection of the shortage of material compared to the other factors. for the second part of the survey we categorized the problems into 4 main categories and each category includes the major reasons lead to material shortage.

We are requesting your assistance in completing the attached questionnaire. It should take approximately 10-15 minutes to complete this survey. The information provided will be used only in support of this research project. All participants will receive a summary report describing the findings of the study (names of participants to remain anonymous).

Please email scanned copy of the completed questionnaire omar_sr2003@hotmail.com , For any question or concern you can email me or call me at +1972-697-9642

We would like to thank you in advance for your assistance.

Sincerely,

2- Responder information and confidential acknowledgment

NON-PARTICIPATION STATEMENT:

Your participation is voluntary, and you may refuse to participate or withdraw at any time without penalty or loss of benefits to which you are otherwise entitled. You may also refuse to answer any question.

CONFIDENTIALITY**:** Every effort will be made to maintain the confidentiality of your participation in this project. The results of this survey will be stored by UTA on a password protected server. Although the data collected will include identifiable information, only the researchers will be able to view it. Furthermore, each participant will be assigned a code number to protect his or her privacy during analyses by the research team. Should you choose to participate in the interviews and focus groups, those conversations will be analyzed using pseudonyms and all conversations will be kept confidential.

RISKS/DISCOMFORTS: The only risks associated with this study are a breach of confidential data from the information collected on the surveys. These risks will be minimized by allowing only the research team members to access the data. If any of the data on survey is downloaded for analysis, it will be saved on password-protect UTA box servers to protect privacy and confidentiality.

ALTERNATIVES: Participation in this project is voluntary and the only alternative to this project is non-participation.

PUBLICATION STATEMENT**:** The results of this study may be published in professional and/or scientific journals. It may also be used for educational purposes or for professional presentations. However, no individual subject will be identified.

VOLUNTARY PARTICIPATION**:** Your participation in this research study is voluntary and you are free to withdraw consent and end your participation at any time without penalty.

Responder Information

Name:

Title:

Phone number:

Email Address:

Location:

Instructions

To complete the survey, select the level of preference of each problem as compared to the reasons listed in the first column of the relevant table by circling the right relationship between each pair of parameters.

S.L Important.....Significantly Less Important

L Important.....Less Important

Important.....Important

M Important.....More Important

S.M Important.....Significantly More Important

For example, in the first table below, if one was to select 2 (L. Important), the indication is that you agree that “Technical reasons” are not the most important problem leading to the “shortage of material.”

Example:

Category 1- Reasons causing shortage of material

	S.L Important	L Important	E Important	M Important	S.M Important
Technical problem	1	(2)	3	4	5

3- Ranking procedures based on Likert scale with 1 being the least important and 5 being the most important.

1…. Significantly Less Important
2…. Less Important
3…. Important
4…. More Important
5…. Significantly More Important

5. Survey Start

A- Evaluate the weight (importance) of the shortage of material to the 20 factors causing delays in construction projects

AHP Level 1

Factors Causing Delay	S.L Important	L Important	Important	M Important	S.M Important
Unrealistic contract duration	1	2	3	4	5
The scope of the project is not well defined	1	2	3	4	5
Poor contract management	1	2	3	4	5
Inadequate early planning of the project	1	2	3	4	5
Inadequate early scheduling of the project	1	2	3	4	5
Late in approving design documents by owner	1	2	3	4	5
Suspension of work	1	2	3	4	5

Table Level 1 Continued

Factors Causing Delay	S.L Important	L Important	Important	M Important	S.M Important
Delay in progress payment by owner	1	2	3	4	5
Poor communication between owner and other parties	1	2	3	4	5
Poor site management	1	2	3	4	5
Poor qualification of contractor's staff assigned to the project	1	2	3	4	5
Shortage of material	1	2	3	4	5
Delay in equipment delivery	1	2	3	4	5
Delay in obtaining permits from Municipality	1	2	3	4	5
Effect of weather	1	2	3	4	5
Traffic control of the project	1	2	3	4	5
Political insecurity	1	2	3	4	5
Economic instability	1	2	3	4	5
Changes in government regulations and laws	1	2	3	4	5
Effects of subsurface conditions	1	2	3	4	5

B- Evaluate the main problems that lead to shortage of material

1-Technical Causes

AHP Level 2

Technical Causes	S.L Important	L Important	Important	M Important	S.M Important
Lack of the accurate and real test for the construction material at the customs location.	***1***	***2***	***3***	***4***	***5***
Lack of accurate code requirement for the construction material to follow at the customs location	***1***	***2***	***3***	***4***	***5***
Lack of the experienced employee understanding the requirement of the code on the customs.	***1***	***2***	***3***	***4***	***5***

2- Experience Causes

AHP level 3

Experience Causes	S.L Important	L Important	Important	M Important	S.M Important
Lack of control over the bad quality and cheap material in the market.	***1***	***2***	***3***	***4***	***5***
Lack of experienced industrial people to run the material manufacturer	***1***	***2***	***3***	***4***	***5***
Lack of experienced owner or supervisors to run the exist material factories.	***1***	***2***	***3***	***4***	***5***
Lack of an experienced consultant and estimator to estimate the need of the material for the project	***1***	***2***	***3***	***4***	***5***
Lack of experience to control construction material on site	***1***	***2***	***3***	***4***	***5***
Lack of consultant knowledge on the availability of material the market	***1***	***2***	***3***	***4***	***5***

3- Governmental Laws Causes

AHP Level 4

Governmental Laws Causes	S.L Important	L Important	Important	M Important	S.M Important
No limitations on specific brands and manufacturers of imports related to project construction material.	***1***	***2***	***3***	***4***	***5***
Lack of government laws on the marketing of construction material.	***1***	***2***	***3***	***4***	***5***
Lack of government laws on the specification of imported construction material.	***1***	***2***	***3***	***4***	***5***
Unstable government code requirement for material.	***1***	***2***	***3***	***4***	***5***
Different requirements for construction material specifications in each government location.	***1***	***2***	***3***	***4***	***5***
Continuous changes in specifications from the government for each project.	***1***	***2***	***3***	***4***	***5***

Table Level 4 Continued

Shutdown of local plants for material production	***1***	***2***	***3***	***4***	***5***
Corruption which prevents the production to make profit from the import	***1***	***2***	***3***	***4***	***5***
Lack of government support to run private material factories	***1***	***2***	***3***	***4***	***5***
Lack of government plans to run public factories.	***1***	***2***	***3***	***4***	***5***
Lack of government plans to build and develop new factories	***1***	***2***	***3***	***4***	***5***
Unstable politics with countries exporting material to Iraq	***1***	***2***	***3***	***4***	***5***
Unstable economy and financial problems	***1***	***2***	***3***	***4***	***5***
Safety problems, especially in material transfers	***1***	***2***	***3***	***4***	***5***

4- Management Causes

AHP Level 5

Management Causes	S.L Important	L Important	Important	M Important	S.M Important
Lack of the sources of the construction material	***1***	***2***	***3***	***4***	***5***
Lack of updates the code requirement according to the market.	***1***	***2***	***3***	***4***	***5***
Lack of material managing system in the project	***1***	***2***	***3***	***4***	***5***
Lack of updating of the availability and the need of material during the project progress	***1***	***2***	***3***	***4***	***5***
Lack of proper plan to storage the material.	***1***	***2***	***3***	***4***	***5***
Lack of proper storage for material in the project	***1***	***2***	***3***	***4***	***5***
Lack of communication between the contractors and the consultant to update the material availability.	***1***	***2***	***3***	***4***	***5***

4- The Structure of the AHP (Analytic Hierarchy Process)

The goal of the survey is to:

a- Determine the effect of the shortage of material on the delay in construction projects in Iraq,

b- Evaluate the shortage of material factor and the weight of it according to the 20 factors selected from the literature review and an expert opinion.

c- Evaluate the problems that led to the shortage of material in each category.

Thanks for your help

Appendix B

List of Acronyms

List of Acronyms

AHP ……. Analytic Hierarchy Process

CPM …… Critical Path Method

CPA ……. Contemporaneous Period Analysis

F. I ……... Index frequency

IMPI ……... Importance Index Method

S. I ……. Severity Index

References

Ahmed, Et.El., Azher, S., Castillo, M., & Kappagantula, P. (2002). Construction Delays In Florida; An Empirical Study. Final report, Florida International University. Retrieved from https://ohlsc.fiu.edu/pdfs/research_reports/delays_project.

Al-Khalil, M., & Al-Ghafly, M. A. (1999). Delay in public utility projects in Saudi Arabia. International Journal of Project Management, 17(2), 101-106).

Al-Kharashi, A. & Skitmore, M. (2009). Causes of delays in Saudi Arabian public sector construction projects. Construction Management and Economics, 27(1), 3-23.

Alotaibi, N., Sutrisna, M., & Chong, H. (2014). Managing Critical Factors Causing Delays In Public Construction Projects In Kingdom Of Saudi Arabia. Curtin University.

Albogamy, A., Scott, D., & Dawood, N. (2012). Addressing Construction Delays in the Kingdom of Saudi Arabia. Centre for Construction Industry Studies, Teesside Universit: Ph.D Thesis.

Albogamy, A., Scott, D., Dawood, N., & Bekr, G. (2013) .Addressing Crucial Risk Factors In The Middle East Construction Industries: A Comparative Study Of Saudi Arabia And Jordan. Sustainable Building Conference.

Apolot, R., Alinaitwe, H., & Tindiwensi, D. (2011). An investigation into the causes of delay and cost overrun in Uganda's public sector construction projects. In Second International Conference on Advance in Engineering and Technology (pp. 305–311).

Arditi, D., Hi, J.J & Cheung, S.O. (2001). Construction delay computation method. Journal of Construction Engineering Management 127, 60-65.

Assaf, S. A., AI-Khalil, M., & AI-Hazm, P. M. (1995). Causes of delay in large building construction projects. Journal of Management in Engineering, 11(2), 45–50.

Assaf, S. A., & Al-Hejji,S. (2006). Causes of delay in large construction projects. International Journal of Project Management, 24(4), 349–357.

Bekr, G. (2016). Uses of delay in public construction projects in Iraq, Jordan Journal of civil Engineering. Computational Statistics & Data Analysis, 48 (1) 159 – 205.

Bell, L.C., & Stukart, G. (1986). Attributes of Material Management Systems, Journal of Construction Engineering and Management Vol. 112, Issue 1 (March 1986), Assoc. Prof., Dept. of Civ. Engrg., Auburn Univ., Auburn, AL 36849.

Bordoli, W., & Baldwin, N. (1998) A methodology for assessing construction project delays, Construction Management and Economics, 16:3, 327-337, DOI: 10.1080/014461998372358.

Business Roundtable Modern Management Systems, A Construction Industry Cost Effectiveness Report A-6 (1982),New York, N.Y.Google Scholar.

Chan, D., & Kumaraswamy, M. (1996), “An evaluation of construction time performance in the building industry”, Journal of Building and Environmental, Vol. 31 No. 6, pp. 569-78.

Duran, X., & O'Regan, B. (2006). A model for assessing the economic viability of construction and demolition waste recycling - The case of Ireland. Resources, Conservation and Recycling. 46. 302-320. 10.1016/j.resconrec.2005.08.003.

Ejaz, N., Ali, I., & Tahir, M. (2013). Assessment of delays and cost overruns during construction projects in Pakistan. Viewed on 13 May 2015, http://www.civil.mrt.ac.lk/ICSECM 2011/SEC-11-69.

Elawi, G.S.A. (2015). Owners’ Perspective of Factors Contributing to Project Delay: Case Studies of Road and Bridge Projects in Saudi Arabia. Arizona State University: Master Thesis.

Emam, H., Farrell, P., & Abdelaal, M. (2015). Causes of Delay on Large Building Projects in Qatar. The 2nd International Conference on Buildings, Construction and Environmental Engineering- BCEE2, Beirut, Lebanon; 10/2015- 10/2015.

Enshassi, A., Al-Najjar, J., & Kumaraswamy, M. (2009). Delays and cost overruns in the construction projects in the Gaza Strip. Journal of Financial Management of Property and Construction, 14(2), 126–151.

Flyvbjerg, B., Mette K. Skamris H., & Soren L. (2002). "What Causes Cost Overrun in Transport Infrastructure Projects?" Transport Reviews, vol. 24, no. 1, January 2004, pp. 3-18.

Frimpong, Y., Oluwoye, J., & Crawford, L. (2003). Causes of delay and cost overruns in construction of groundwater projects in developing countries; Ghana as a case study. International Journal of Project Management, 21(5), 321–326.

Fugar, F. D. K., & Agyakwah-Baah, A. B. (2010).Delays in Building Construction Projects in Ghana. Australasian Journal of Construction Economics and Building, pp.103-116.

Gardezi, S.S.S., Manarvi, I.A., & Gardezi, S.J.S. (2013).Time Extension Factors in Construction Industry of Pakistan .Fourth International Symposium on Infrastructure Engineering in Developing Countries (IEDC). Procedia Engineering 77 (2014) 196 – 204.

Goepel, K.D. (2018). Implementation of an Online Software Tool for the Analytic Hierarchy Process (AHP-OS). International Journal of the Analytic Hierarchy Process, Vol. 10 Issue 3 2018, pp 469-487.

Haseeb, M., Xinhai-Lu, Bibi, A., Maloof, U., & Rabbani, W. (2011). Problems of projects and effects of delay in the construction industry of Pakistan. Australian Journal of Business and Management Research, 1(5), 41- 50.

Hasan, R., Suliman, S. M. A., & Malki, Y. Al. (2014). An investigation into the delays in road projects in Bahrain. International Journal of Research in Engineering and Science (IJRES), 2(2), 38–47.

Http://iraqbuild.org/. Iraq reconstructing plan 2020-2025 visited on 10/25/2019.

Http://www.opec.org/opec_web/en/. Iraq oil production visited on 10/10/2019.

Kaushal, V., Najafi, M., Serajiantehrani, R., & Malek Mohammadi, M. (2020). Social Cost Comparison of CIPP with Open-cut. Proc. ASCE Pipelines 2020, San Antonio, TX.

Khadduri, M, Blake, G.H., Kennedy, H., Chambers, R.L., & Woods, J.E. 2019. Encyclopedia Britannica, “Iraq” online at https://www.britannica.com/place/Iraq

Kikwasi, G. J. (2012). Causes and effects of delays and disruptions in construction projects in Tanzania. Australasian Journal of Construction Economics and Building, Conference Series, 1(2), 52–59.

Kraiem, Z.M., & Dickmann, J.E. (1987) ‘Concurrent Delays in Construction Projects, ,ASCE Journal of Construction engineering and Management, 113 (1987), pp.591-602.

Mahamid, I. (2013). Contributors To Schedule Delays In Public Construction Projects In Saudi Arabia: Owners’ Perspective. Journal of Construction Project Management and Innovation, Vol. 3 (2): 608-619.

Mahamid, I. (2014).Micro and macro level of dispute causes in residential building projects: Studies of Saudi Arabia. Journal of King Saud University – Engineering Sciences. http://dx.doi.org/10.1016/j.jksues.2014.03.002.

Masood, R., Ali, M., Shafique, F., Shafique, M. A., Zafar, B., & Maqsoom, A. (2015). Investigating the Delay Factors of Construction Projects in Metropolitan City of a Developing Country. Journal of Civil Engineering and Architecture Research, 2(9), 947-955.

Menesi, W. (2007). Construction Delay Analysis under Multiple Baseline Updates. University of Waterloo: Master Thesis.

Memon, A. H. (2013). Structural Modelling of Factors Causing Cost Overrun in Construction Industry University Tun Hussein O2013nn Malaysia: Ph.D Thesis.

Mohammed, A. (2017). Study and Analysis of the Delay Problems in Iraqi Construction Projects. International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391 Volume 6 Issue 5, May 2017 www.ijsr.net Licensed Under Creative Commons Attribution CC BY Study and Analysis of the Delay Problems in Iraqi Construction Projects.

Nagapan, S. (2016). Categorization of Saudi Arabia's Construction Delay Factors Using Factor Analysis Technique. 3rd International Conference on Civil, Offshore & Environmental Engineering 2016 (ICCOEE2016) Kuala Lumpur Convention Centre, Malaysia 15-17 August 2016.

Nashwan, A., & Nagapan, S. (2016). Projects Delay Factors of Saudi Arabia Construction Industry using PLS-SEM Path Modelling Approach. International Conference on Engineering Design and Analysis (ICEDA 2016) Langkawi, Malaysia July 29-31, 2016. Accepted and Indexed by Scopus

Nashwan, A., & Nagapan, S. (2015). Identification of Delay Factors from Mecca's Construction Experts Perspective. International Journal of Sustainable Construction Engineering & Technology (IJSCET), Vol 6, No 2, pp.1-4. (ISSN: 2180-3242).

Pai, S. K., & Bharath, J. R. (2013). Analysis of Critical Causes of Delays in Indian Infrastructure Projects. International Journal of Innovative Research & Development, 2(3), 251–263.

Park, M., Kim, W., Yoon, Y., & Nepal, M. P. (2010). "Scheduling decisions and their dynamic consequences on construction performance." KSCE Journal of Civil Engineering, 14(3), 251-259.

Peng, U., Kou, G., Wang, W. & Shi, Y. (2011) Ensemble of software defect predictors: An AHP-based evaluation method, International Journal of Information Technology & Decision Making 10(1) 187-206, doi:10.1142/S0219622011004282.

Pressoir, S. "Are You Contracting for Success?" American Association of Cost Engineers (AACE), International's Professional Practice Guide to Contracts and Claims, AACE Transactions. Morgantown, WV, (1992).

Rahman, A. & Nagapan, S. (2016). Categorization of Saudi Arabia's Construction Delay Factors Using Factor Analysis Technique. 3rd International Conference on Civil, Offshore & Environmental Engineering 2016 (ICCOEE2016) Kuala Lumpur Convention Centre, Malaysia 15-17 August 2016. Accepted and Indexed by Scopus.

Saaty, T.L., (1980). “The Analytic Hierarchy Process.” McGraw-Hill, New York

Saaty, T.L. (2008). Decision making with the analytic hierarchy process, International Journal of Services Sciences 1(1) (2008) 83–98.

Sambasivan, M., & Soon, Y. W. (2007). “Causes and effects of delays in Malaysian construction industry.” Int. J. Proj. Manage. 25: 517–526.

Serajiantehrani, R., Janbaz, S., Najafi, M., Korky, S., & Malek Mohammadi, M. (2019). Impact of Tunnel Boring Machine Advance Rate for Pipeline Construction Projects. Proc. ASCE Pipelines 2019, Nashville, TN, (pp. 650-660).

Serajiantehrani, R. (2019). Development of Machine Learning-based Prediction Model for Construction and Environmental Costs of Spray-applied Pipe Linings (SAPLs), Cured-in-place Pipe (CIPP), and Sliplining in Large Diameter Culverts. Doctoral Dissertation, University of Texas, Arlington, TX.

Soni, S., Pandey, M., & Agrawal S. (2017). Evaluation of Factors Causing Conflicts & Dispute in Construction Projects by AHP & IMPI Method. International Research Journal of Engineering and Technology (IRJET), vol 4(6).

Susmitha, A. (2018), A STATISTICAL APPROACH FOR RANKING OF FACTORS IMPACTING THE TIMELINE OF RESIDENTIAL CONSTRUCTION PROJECTS USING IMPORTANT INDEX METHOD (IMPI) International Journal of Civil Engineering and Technology (IJCIET) Volume 9, Issue 5, May 2018, pp. 1075–1083, Article ID: IJCIET_09_05_120.

Sweis, G., Sweis, R., Hammad, A.A., & Shboul, A. (2007). Delays in construction projects: The case of Jordan. International Journal of Project Management, 26(6), 665–674

Trost, S. M., & Oberlender, G. D. (2003). Predicting accuracy of early cost estimates using factor analysis and multivariate regression. J. Constr. Eng. Manage, 129(2), 198–204

Tumi, S. A., Omran, A., & Pakir, A. K. (2009). Causes of delay in construction industry in Libya. The International Conference on Economics and Administration (ICEA). Faculty of Administration and Business, University of Bucharest, Romania.

Biographical Information

In June 2011, Omar Abdullah graduated with a Bachelor of Science degree in Civil Engineering Degree from the University of Technology at Baghdad, Iraq. He started work on his Master of Science degree in Civil Engineering with a focus in Construction Engineering and Management at the University of Texas at Arlington in the spring semester of 2018. While pursuing his Master's degree, he was working with Copart Construction in the Dallas area as project manager. He received his Master of Science in Civil Engineering in December 2019.