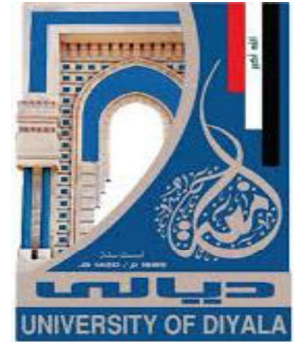


**Ministry of Higher Education
and Scientific Research
University of Diyala
College of Engineering**



**The integration of Risk management and BIM to
Manage the duration of construction projects**

**A Thesis Submitted to the Council of College of Engineering
University of Diyala in Partial Fulfillment of the
Requirements for the Degree of Master of Science in Civil
Engineering**

**By
Noor Haider Kadum
BSC. Civil Engineering, 2014**

**Supervised by
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2021 A.D

IRAQ

1443 A.H

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

" هُوَ الَّذِي جَعَلَ الشَّمْسَ ضِيَاءً وَالْقَمَرَ

نُورًا وَقَدَرَهُ مَنَازِلَ لِتَعْلَمُوا عَدَدَ

السِّنِينَ وَالْحِسَابِ مَا خَلَقَ اللَّهُ ذَلِكَ إِلَّا

بِالْحَقِّ يُفَصِّلُ الْآيَاتِ لِقَوْمٍ يَعْلَمُونَ "

صدق الله العلي العظيم

(يونس - 5)

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Prof. Dr. Khattab S. Abdul-Razzaq (Head of Department) The thesis was ratified at the Council of College of Engineering / University of Diyala.

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Dean of College of Engineering / University of Diyala

Date:

Dedication



I want to dedicate this study to:

my dear father

**"His words of encouragement in the pursuit of
excellence"**

My Affectionate Mother

**"Whose love and prayers took me to the zenith of
glory and transform my dreams into reality"**

my husband

"Which always encouraged and supported me"

My lovely daughter; my sisters ; my brothers

Finally; to My Friends.

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First and foremost, I thank God for his grace and blessings, and for the patience, perseverance, and high spirit he has given me.

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Abstract

The integration of Risk management and BIM to Manage the duration of construction projects

By

Noor Haider Kaduom

Supervised by:

Prof . Hafth Ibrahim Naji

The special nature that characterizes construction projects in Iraq, the multiplicity of its stages from the idea stage to the end of the delivery stage, and the weakness in the application of risk management makes it vulnerable to many risks that have a unique impact on its basic objectives. The identification and management of risks in construction projects is an important approach to reduce their impact and increase the chances of success of the construction projects.

The research aims to identify the most important risk factors facing construction projects in Iraq, provide a tool based on the integration between risk management and BIM technology to manage the risks that effect the duration of construction projects, and help the project manager to understand the impact of risk management and taking measures for controlling the risks in construction projects.

In order to achieve the research objectives, the literature and previous studies related to the topics of risk management and BIM technology were reviewed and selects one of the Iraqi projects as a case study for applying the idea of the research. After that, the researcher identifies and assesses the risks that face the construction projects by using qualitative and quantitative techniques represented by the

questionnaire, personal interviews, probability and impact matrix, Monte Carlo simulation. Finally conducting the integration between risk management and BIM through using tools provided by the BIM technique (Autodesk Revit 2020, Navis work manage2020) that helps for achieving the research objectives

The study diagnosed 48 risk factors that represent the most common risks in construction projects in Iraq, and reached a predictive model for risks by adopting two scenarios for the likelihood of risk occurrence and its impact on construction projects. From the approved scenarios comparison, the probabilistic percentage for completing the project was 109% of the planned percentage of project completion, and for the pessimistic scenario the probabilistic percentage of project completion was 334% and 774% for (case 1) and (case 2), respectively.

The integration between risk management and BIM technology is a simulation of a 4D building model that visualizes the effect of risks on project progress and shows the delayed activities and allows the comparison between the planned and actual project progress in a visual format.

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List of Symbols and Abbreviations	
<i>Abbreviations</i>	<i>Explanation</i>
BIM	Building Information Modeling
2D	Two Dimension
3D	Three Dimension
4D	Four Dimension
5D	Five Dimension
6D	Six Dimension
FMEA technique	Failer Mode and Effect Analyses Technology
SPSS	Statistical Package for Social Sciences
RM	Risk Management
MCS	Monte Carlo Simulation
IFC	Industry Foundation Classes
GBS	Green Building Studio
$C\alpha$	Cronbach's Coefficient Alpha
Ms. Project	Microsoft Project
XML	Extensible Markup Language
MPX	Microsoft Project Exchange
MCS	Monte Carlo simulation
AEC Industry	Architecture, Engineering and Construction Industry

CHAPTER ONE

Introduction

Chapter One

Research Introduction

1.1 Introduction

Construction projects exposed to severe and multiple risks during their lifecycle beginning from the stage of decision-making to the project delivery stage. Risks in generally described as events that impact the project objectives, and cause delays in the project delivery or increase the project cost, and in sometimes impact the project quality. (Rasheed,2015).

The risk management process has been becoming one of the important requirements for construction projects and it includes the identification of risk, the assessment of risk, the response to the risk, and the monitoring of risk (Abd El-Karim et al.,2017).

The application of some modern techniques is necessary for attaining the proper solutions under accurate consideration (Ardeshir et al.,2018). At present, most enterprises of construction headed for using BIM technology for their projects (Lam et al., 2017), BIM technology provides an environment that is easy for project design, modification of the 3D building model, as well as storage the data for the 3D model for the building(Eastman et al, 2011). Another feature of BIM technology is the ability to share information between different parties of the project during the different project stages (Jupp, 2017). Based on features and characteristics previously described by BIM technology, this technique can be used as a tool for managing risk (Bråthen & Moum, 2016), which is an important process during the planning and construction of the project(Zou et al., 2017). BIM helps the dealing with the complexity of the projects that impact the main objectives of construction projects

(Bryde et al., 2013). also, the BIM technique facilitating the communication between all parties of the project for reaching successful management of risk in the construction projects(PMI, 2013).

This chapter provides an introductory overview to illustrate the research that has been made, the research justifications, the research hypothesis, describe the research aim and objectives. In addition, clarify the research limitations and research methodology is specified, as well as discussing previous studies.

1.2 The Research Justification

The research justification can be illustrated as follows:

1. Construction projects in Iraq face many risks in the implementation stage that causes stoppages of the projects and not to complete them within the specified period. Therefore, there is a need to manage these risks and try to address them to maintain the basic objectives of the construction project, which are cost, time, and quality.
2. The need to use and develop a system to diagnose the risk and evaluating them based on the integration of risk management techniques with BIM as a means of controlling the inherent risks of construction projects.
3. Despite the complex nature of the decisions to enter the construction market, the existing methods and tools for evaluating construction opportunities are preliminary and are generally based on personal intuition or previous experience, both of which are easily affected by uncertainty and bias and therefore the construction companies needs for effective and comprehensive methods to manage uncertainties in their projects.

1.3 Research Hypothesis

Based on the justifications mentioned above, it has been possible to formulate the research hypothesis as follows:-

To prove the possibility of integration between risk management and BIM to develop a methodology that will help to make the right and correct decisions regarding the risks facing construction projects and address them, which leads to the successful completion of the implementation of the project within its objectives.

1.4 Research Aim and Objectives

This research aims to diagnoses the risks that affect the duration of construction projects in Iraq and managing the identified risks by developing a hybrid technology that uses risk management techniques in conjunction with BIM to assess and address the risks that hinder the successful completion of the construction project.

For achieving these aims of the current research , there are some objectives that must be achieved as follows:

1. Diagnoses the most common risk factors in construction projects and identify the probability of risks occurrence and its impact on the construction projects.
2. Conduct the quantitative risk evaluation by using modern technology and put the required measures for responding to them.
3. Building a predictive model for managing risks.
4. Showing the quantitative risk evaluation in a visual format.

5. Investigating the characteristics provided by the BIM technique in evaluating and responding to risks in construction projects.

1.5 Research Limitations

The research limitation can be illustrated as follows:

1. Identify , analyze and respond to the risks that occur through the implementation of construction projects.
2. Selecting student dorms No. (1) and No. (2) at the University of Diyala as a case study.
3. Selecting the construction and housing sector as a research sample for distribution of the questionnaire.
4. The implementation duration of the projects involved in the research was limited to the period between (1/1/2012 - 1/2/2021).
5. Temporal limitation: The research duration was limited to the period of 2020-2021.

1.6 The Research Methodology

The research methodology adopted in the current research includes two parts and can be illustrated as follows:

2.1 Part one (theoretical part): This part includes reviewed the literature for the previous studies within the scope of the research which includes (papers, thesis, websites and books).

2.2 Part two (practical part):

The practical part of the current methodology is including the following:

1. Identify case study and collect information which includes (2D drawing, data, project duration, bill of quantities.)
2. Generating a 3D model for the building by using Autodesk's Revit 2020 with several details.
3. Design a questionnaire for defining the most common construction project risk that affects construction projects in Iraq.
4. Conduct the qualitative risk analysis by using probability and impact matrix technology .
5. Scheduling the project details (start, finish and duration) by using MS Project 2010.
6. Importing the construction project schedule to risky project professional 7.1 by intaver for quantitative risk analysis.
7. Scheduling the simulated duration obtained from the quantitative risk analysis.
8. Generation 4D simulation for the building by using Navisworks manage 2020 by Autodesk
9. Discuss the effect of risk on project duration through the simulation result and conclusions and recommendations reached by the researcher.

Figure (1.1) shows the research methodology adopted in case of study

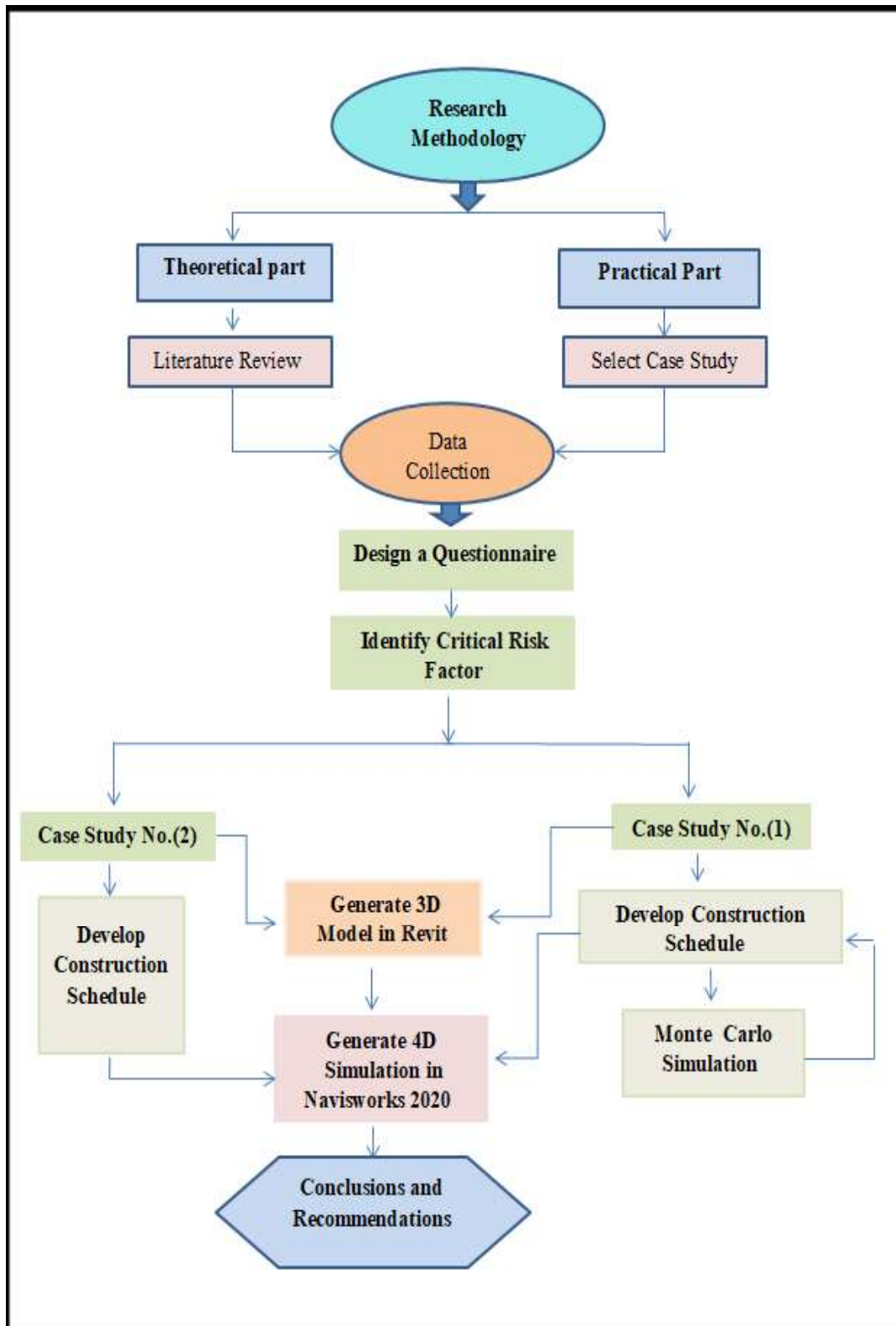


Figure (1.1) The research methodology (Researcher)

1.7 Research Organization

The organization of the research is divided into five chapters :A summarized description for each chapter is illustrated below.

Chapter One: Research Introduction

This chapter introduces the research background, research Justification, research hypothesis, research aims and objectives, research limitation, a brief explanation of the research methodology, and explains the previous studies.

Chapter Two: Literature Review

This chapter illustrates the basic theoretical literature review in the scope of the research for understanding the entire work contained in this thesis. This chapter includes two main parts: The first part explains the concept of risks, the concept of risk management, and its importance, the methodology that adopting for managing risks in construction projects, the stages of risk management, and its techniques. The second part explains the concept of BIM in project management, its dimensions, its advantages and possibilities, BIM and Risk management, Contributions of BIM in risk management, and finally, describe the BIM-related techniques for managing risks in construction projects.

Chapter Three: Field Study

This chapter explains the field questionnaire, The sources of data for the field study, the questionnaire design, the mathematical and statistical methods used in the data analysis, the qualitative risk analysis and explain the details of the case studies, the reasons for selecting case studies, ,and finally explain the software tools that used in current research.

Chapter Four: Integration BIM Technique with Risk Management

This chapter explains the modeling of the proposed methodology for the two cases in the current research, the generating of the 3D model for the building as well as creating a construction project schedule, conducting the quantitative risk analysis by using the Monte Carlo simulation technique and analysis and discussion the results, conducting 4D simulation for the building by using Navisworks 2020.

Chapter Five: Conclusions & Recommendations

This chapter illustrates the major conclusions and recommendations, as well as the suggestive of future studies.

1.8 Review of Previous Studies

Many studies in the field of risk management have been conducted by a number of researchers in different countries. Table (1.1) illustrates the previous studies related to managing risks in construction projects. The studies were divided into two groups (local studies , and global studies) according to their geographic location.

Table (1.1):Review of previous studies

Local Studies (Iraqi studies)				
NO.	Researcher	Country	Methodology of Analysis	Software used For Statistical Analysis
1	(Wali & Mahmood, 2020)	Iraq	<ul style="list-style-type: none"> • Questionnaire survey • likelihood and severity matrix 	<ul style="list-style-type: none"> • Microsoft Excel

The work :Risk management				
Identification and Management of Major Risk Factors in Construction of Healthcare Centers Projects				
<p>This paper studied the risk factors that facing the construction process of advanced healthcare centers by identifying these factors and enhancing the possible solutions depending on the opinion of experts. Government corruption represents the major risk factor that has a negative effect on the construction of infrastructure in the country. Other risk factors were the overrun of time, labor safety, environmental risks, which are related to waste treatment.</p>				
2	(Mohanad,2019)	Iraq	<ul style="list-style-type: none"> • questionnaire survey • RIII • Monte Carlo Simulation • sensitivity analysis. 	<ul style="list-style-type: none"> • Primavera risk analysis v8.7 software • SPSS v 33
The work :Risk management				
The Effect of Inadequate Risk Management on Execution Time of Residential Complexes in Iraq				
<p>This research aimed at identifying the most significant risk factors and their impact on the execution time of complex construction projects and managing these risks. This study performs that by adopting the qualitative and quantitative techniques that representing by questionnaire, relative importance, Monte Carlo Simulation by using primavera risk analysis v8.7 software, and the sensitivity analysis. This study found that the most significant risk factors and have the most effects were implementing works that non-conforming to specification, inaccuracy of the schedule, delaying the payment of the advances according to the contract with a risk score for each risk factor (0.534), (0.527), and (0.498) respectively. Also, the study found that risks have different effects according to the size of the residential project.</p>				
3	(Shadhar &	Iraq	<ul style="list-style-type: none"> • Questionnaire 	<ul style="list-style-type: none"> • Not mentioned

	Mahmood,2018)		<ul style="list-style-type: none"> survey Personal interviews 	
The work :Risk management				
Risks of Design Stage in Iraqi Construction Project				
<p>This study focused on identify and analyze the risks of the design stage and its effect on construction projects. The study clarifies that the effect of the design stage depends on the method of contracting with the company where the Lump-sum contract type was the most type of contract that affects the project and more effect from unit price contract .During the design stage, the most important factor that effects were the fast responding of the project team for preparing the design documents for facilitating the sequence of execution.</p>				
4	(Ali,2017)	Iraq	<ul style="list-style-type: none"> Questionnaire survey Neural Network Decision tree Support Vector Machine 	<ul style="list-style-type: none"> MATLAB 7.11.0 SPSS
The work :Risk management				
Managing Of Cost Risks Generated From Risk Responses In Construction Projects				
<p>This research studied cost risk management generated from responding to risks in construction projects and controlling them by adopting quantitative and qualitative methods of risk management by using simulation technique (system dynamic), Fuzzy decision tree. The study finding of risk responding strategy illustrates as follow: the strategy of investment show saving in cost 30%, mitigation strategy show saving in costs 40%, the strategy of giving land to contractor show save in the cost about 40% finally the strategy of BIM show saving in cost about 25%.</p>				
5	(Aksana Jihad,2016)	Iraq	<ul style="list-style-type: none"> Questionnaire survey The Relative Importance Index 	<ul style="list-style-type: none"> SPSS Software
The work : Risk management				
A Study For Significant Risks And Their Effects On Construction Projects In Erbil City				

	<p>This study aimed at identifying the top major of 50 risk factors by contractors, owners, and engineers according to their probability occurrence and impact on projects also analyzing the effect of these risks on cost, time, quality of the construction projects. The study finding that the most significant factors of risk are: the owner inability for financing, awarding the design of projects to unqualified designers, poor experience , qualifications &skills of technical staff and contractor, the defective design, poor supervision and qualifications of the owner’s engineer, and delay in the approval of inspection and tests and these risks result from four risk factors: the owner, management, the contractor, and the consultant.</p>			
Global Studies				
1	(Hiyassat et al. ,2020)	Jordan	<ul style="list-style-type: none"> • literature review • questionnaire survey • relative Importance Index (RII) 	<ul style="list-style-type: none"> • Microsoft Excel
The work :Risk management				
Risk allocation in public construction projects: the case of Jordan				
<p>This research tried to identify, assess, and allocate the public construction projects (PCP) risks in Jordan for reducing the costly claims and disputes. The finding of this study is that delays in client payments were the top risk factor and the owner should shoulder such a risk according to the result of the respondents who indicated that. On the other hand, supplier default and decrease in productivity represent the two top factors that should be shouldered by contractors. The study results help practitioners for allocating risks to the party that have the ability for assessing, controlling, and managing these risks.</p>				
2	(Gebrehiwe et al. ,2019)	China	<ul style="list-style-type: none"> • TOPSIS technique • FCE technique • Questionnaire 	<ul style="list-style-type: none"> • Not mentioned
The work :Risk management				
Risk Level Evaluation on Construction Project Lifecycle Using Fuzzy Comprehensive Evaluation and TOPSIS				
<p>This study discusses the evaluation of risks in case of occurring schedule</p>				

	delays at the different stages of the construction projects. The study finding that the construction stage influenced in highly with a percent of(44%), the second stage that highly influenced is post-construction with a percent of (37%), and the least influence stage that is pre-construction (35%). The study expected for using this work as a tool to helps managers for managing and control schedule delays to eliminate project risks.			
3	(Swapnesh et al.,2017)	India	<ul style="list-style-type: none"> • 3D BIM model • 4D BIM model 	<ul style="list-style-type: none"> • Autodesk Revit 2016 • Navisworks Manage 2016
The work :4D Simulation				
Improve the Productivity of Building Project using Building Information Modelling (BIM) Based 4D Simulation Model				
This study aimed to explain 4D BIM for improving project coordination, communication, and sharing the project information between all project teams which is important in terms of performance and time of projects. This study finding that BIM provides advanced construction management skills for scheduling the project activities, monitoring, and controlling. Also, the study concluded 4D BIM represents the best alternative to traditional scheduling tools of construction projects like bar charts, CPM networks .				
4	(El-Karim et al.2017)	Egypt	<ul style="list-style-type: none"> • Questionnaire • Risk Score • AHP analysis • Sensitivity analysis 	<ul style="list-style-type: none"> • Microsoft Excel
The work :Risk management				
Identification and assessment of risk factors affecting construction projects				
This study aimed for identifying, studying, qualitative assessing, quantity assessing the effects of the factors that impact cost and time contingency. The finding by this study that the estimating cost and schedule contingencies represent the major factors to achieve successful and realistic budget and construction schedule for the projects.				
5	(Marco Petrus,2017)	Portugal	<ul style="list-style-type: none"> • conceptual model • FMEA technique 	<ul style="list-style-type: none"> • BIM • Excel • Daynamo

			<ul style="list-style-type: none"> • 3D modeling • 4D modeling 	<ul style="list-style-type: none"> • Navisworks
The work :BIM with Risk management				
A BIM-based tool to support time risk management in construction projects				
<p>This study tried to visualize different risks related to the time and cost during the design and implementing stages by using a tool that can be helping to understand the time and cost-related risks of the construction project and helping to improve the communication between all project parties. The study concluded the tool was an efficient communication. The FMEA interface and models constitute reliable information that helps the project manager for providing to all stakeholders in the project such as the client of the project, workers, subcontractors.</p>				
6	(Bonander & Ulriksson,2016)	Sweden	<ul style="list-style-type: none"> • Personal interviews 	<ul style="list-style-type: none"> • Not mentioned
The work :Risk management				
Risk Management in Residential Construction - An analysis of the risk management process of a Swedish construction company				
<p>This study aimed for describing and analyzing the process of risk management in a project-based organization in the industry of construction and provide a better understanding of the usage of risk management in practice and what underlying factors that affect the risk management process. The study includes the perspective of the constructor and developer. The study found that the risk management process depends on project members' personal knowledge and experience. Also, it was found that constraints of time and resources affect active work with risk management and this leads to conducting the risk management process periodically, instead of continuously throughout the project life cycle . And these obstacles can be avoided through more prioritizing of the risk management process and awareness increasing of its significance.</p>				
7	(Dayoub & Zrika,2016)	Syria	<ul style="list-style-type: none"> • Questionnaire 	<ul style="list-style-type: none"> • SPSS software
The work :Risk management				
Risk Identification in Construction Companies: A Field Study on Construction				

Companies Working in Syria

This study aimed to identify risks in construction companies in Syria. The study findings that inflationary risks (hand labor wages, transportation costs, materials cost) represent the main factors of risks that facing the Syrian construction companies. Also, the absence of the culture of construction management represents the major threat because it does not show the risk and its effects .

1.9 Brief Description about the Research

This research explores to study the ability for using BIM technology in the field of risk management in construction projects in Iraq. Where the researcher tries for taking advantage of the benefits provided by the BIM technology represented by visualization and simulation for creating a dynamic environment that is similar to the real work environment by integrating the results of the quantitative risk analysis with a 3D model, which facilitates project managers for better understanding the project risk management and thus provides accurate identification of risks compared with traditional methods for risk management. previous studies used different methods for managing risks in construction projects. many of these studies used traditional techniques for managing risks in construction projects. Other studies used BIM technology in supporting time risk management and others used BIM for improving project productivity depending on 4D simulation. These studies did not use risky project software for quantitative risk analyzing and responding and did not show the quantitative risk analyses in a visual format.