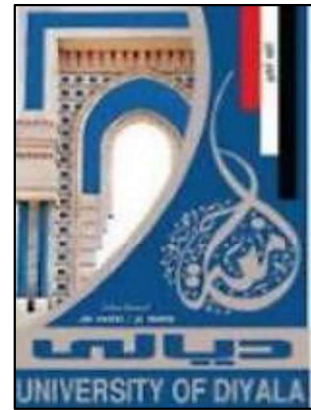


**Ministry of Higher Education
and Scientific Research
University of Diyala
College of Engineering**



Improving the Execution Monitoring Quality and Materials Alternatives Using BIM

**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
Jinan Adnan Aboab
BSC. Civil Engineering,
2001

Supervised by
Prof. Dr. Wadhah Amer Hatem

2022 A.D

IRAQ

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

﴿ قالوا سبحانك لا علم لنا الا ما علمتنا

﴿ انك انت العليم الحكيم

صدق الله العظيم

الآيه (32) سورة البقره

DEDICATION



**I dedicate this study with much gratitude and love to;
My Dear Father;
His words of inspiration and encouragement in pursuit of
excellence.**

My Affectionate Mother;

Who have always encouraged and supported me,

My Family

Finally, to My Friends.



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Abstract

Quality is an important criterion for the evaluation of successful and sustainable building projects. And, it is the most important element of building a project beside time, and cost, for achieving the principles of quality management on performance by integrating all modern engineering concerns and linking them with quality requirements and directing its course to achieve a high quality product or service. Therefore quality management expanded its limits as it has become closely linked to modern technologies such as Building Information Modeling (BIM) technology. BIM technology is one of the modern integrated technologies, as it includes all the common operations of the construction project.

This research aims to study the possibility of adopting BIM technology to develop a proposed system to improve the quality of the construction projects implementation in Iraq in integration with modern engineering techniques. This system includes quality control and quality assurance.

To achieve the objectives of this research, a review of the literature and previous research was conducted and a questionnaire was prepared for the purpose of assessing the quality of construction projects in Iraq, and to determine if the use of modern software such as Building Information Modeling (BIM) control is the quality of execution in the construction sector and its analysis using the program (IBM SPSS-V26).

Although, many difficulties encountered by this work due to the different scientific methodology and different points of view in the application of these techniques in reality. However, this study focused on the application of these techniques in the field, and this step was supported by the practical study, where the Ghalibya Residential Complex was adopted as a case study that was modeled in this research through data collection. The project was conducted through personal interviews with the cadre of the resident

engineer responsible for the project. The digital pictures of the building were also taken using the (Agisoft) program and photogrammetry. The case study (as built) was modeled to monitor the quality of the project's performance, where all stages of project implementation can be documented with high accuracy. The model was imported into the Recap program to process the origin and data point, and then the model was exported to the Rivet program to prepare the modeling of the building and extract the quantities for the main activities of the building, where these techniques can be used to improve the quality of control for construction projects. Also, BIM technology was used, depending on a tool green building studio (GBS) to analyze the energy consumption of the study case and choose the best alternatives for the application.

Finally, the questionnaire results indicated the poor quality of construction projects depending on total average for (mean=2.3, SD=0.93) and weak project management responsibilities, due to depending on traditional methods based on the total average for (mean=2.3, SD=0.9) and non-compliance for the use of modern software as (BIM) to control the execution quality.

The results clearly manifested the ability of the integration of modern technologies to show a modeling of the project based on photogrammetry, where the accuracy of the measurement of dimensions reached 99.8%, with an error rate ranging within (0.8-10) cm. The accuracy of calculating the quantities was between actual and BIM (98.6%). The accuracy of the quantities is between the estimation and BIM (94.9%). Some materials that had comprehensive qualities in improving the quality of the building were also selected, such as granite in the finishing of the external walls and cellulose insulating material, as well as foam materials can be used on the roofs, as they are considered materials resistant to weather conditions and high temperatures and also reduce the energy consumption of the building

compared to other materials. This was done by adopting the BIM technology for energy analysis. As well as according to the opinion of experts and engineers to evaluate the proposed system, a questionnaire was used, where the end result was the acceptance of the proposed system by 95%.

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List of Abbreviations

Abbreviations	Explanation
2D	Two Dimension
3D	Three Dimension
4D	Four Dimension
5D	Five Dimension
6D	Six Dimension
7D	Sevene Dimension
AEC	Architecture, Engineering and Construction
BIM	Building Information Modeling
BPA	Building Performance Analysis
CAD	Computer Aided Design
GBS	Green Building Studio
QA	Quality Assurance
QC	Quality Control
QMS	Quality Management System
QTO	Quantity Take-Off
RII	Relative Importance Index
SD	Standard Deviation
SfM	Structure From Motion
SPSS	Statistical Package for Social Sciences
TQM	Total Quality Management
UAVs	Unmanned Aerial Vehicles

CHAPTER ONE

INTRODUCTION

CHAPTER ONE

Introduction

1.1 General

The construction sector is considered one of the most vital sectors in Iraq. It is known that the majority of construction projects in this country may not be completed within the project specifications. The reality of the field of construction projects in Iraq is related to the need to develop the performance to improve the quality, time, and cost management, and therefore there is a need to use modern software as building information modeling to control the quality of execution.

Science and technology are developing by the day. Building Information Modeling (BIM) was merely a moniker expressing a cutting-edge notion a few years ago for most people. It is now widely used and popular in the Architecture/ Engineering/ Construction (AEC) profession in the majority of nations throughout the world. One of the administrative challenges that the managers of building projects in Iraq encounter is updating the information and data to determine the quality of performance (Amer et al. 2021). Construction project management must have a clear vision and goal in order to plan, execute, and evaluate its performance on a continuous basis, especially in an uncertain work environment (Mahmoud 2020).

Quality is one of the main factors in the success of construction projects. Quality of construction projects, as well as project success, can be regarded as the fulfillment of expectations. Some design professionals believe that the quality is measured by the aesthetics of the facilities they design. while a new term for quality that has emerged as quality 4.0 is an extended approach to quality management, where the recent technologies are being integrated with traditional quality practices (Quality Control (QC), Quality assurance (QA), and Total Quality Management (TQM)) to expand the quality management scope and to improve the quality activities (Sader Sami 2021).

One of these techniques is building information modeling (BIM), which represents a technical and operational shift in the construction industry (Succar 2009).

Building Information Modeling (BIM) is a sophisticated technology and technique that combines virtual features, systems, and concepts in a single environment (WoonSeong and Son 2015). Several BIM applications may be utilized to aid in quality inspection constructability, control, analysis, scheduling, cost estimates, and time sequencing (Takim and Harris 2013). One of the key advantages of BIM is the accurate geometrical representation of architectural elements within an integrated information environment (Amer et al. 2018). BIM execution necessitates careful planning and a coordinated strategy that takes into account the implementation and innovation management (Migilinskas et al. 2013). The purpose of this research is to improve the quality of implementation in construction projects by making a virtual prototype of a building in a residential complex by using digital cameras and drone cameras during Agisoft, Recap software, and Revit software. In addition, it aims to improve and assure the quality of construction projects by reducing their energy consumption, where the study gave a proposal for a special system to monitor, ensure and continually improve the quality in the implementation phase using several BIM applications.

1.2 Research Justifications

Chapter three from this thesis explains the justifications for this research and the most important points by distributing questionnaires for the people who work in the execution for construction projects, and there are some points that can be summarized as follows:

- 1- The lack of appropriate technologies.
- 2- The need to use modern technologies such as BIM to improve quality of construction project during execution stage.

3-Implementing a system for improvement execution in construction project in Iraq is necessary and beneficial.

1.3 Research Aim and Objectives

The aim of this research is to propose a quality improvement system to control, assure, and improve the quality of Iraqi projects using BIM and its applications that revolve around improving the project quality in the implementation phase and there are some objectives besides the main aim as follows:

1. Increasing the quality control and performance enhancement through performance monitoring in the construction project implementation works.
2. Increasing the quality assurance using BIM by the administration by appointing a quality manager who has sufficient experience with the general specifications in quality control.
3. Achieving total quality to ensure a continuous improvement during the execution phase.

1.4 Research Scope and Limitations

The research scope and limitations include the following points:

- 1- Research scope: This study was applied in the execution stage.
- 2- Spatial limitation: The research included the execution stage of the study case Diyala governorate of the Al- Ghalibyah Residential Complex (condominiums).
- 3- Temporal limitation: It covers the period 2021-2022.

1.5 Research Methodology

The methodology of the research is mainly divided into two parts: Theoretical study and practical study, as shown in figure (1-1):

A- Theoretical study:

This part includes reviewing the pertinent literature; covering the previous researches and scientific references including books,

conferences, journals, and magazines that discussed improving the quality using BIM.

B- Practical study:

The practical part of the research includes:

1. Questionnaire design: The questionnaire approach was used to assess the utilization of quality in building projects. It includes questions distributed to respondents working in the construction sector to express their opinion on the quality of construction projects in Iraq, as well as the extent of their knowledge of modern engineering techniques (BIM) and their relationship to the development of the quality system in construction.
2. Analyzing the results of the questionnaire and statistical analysis using the (SPSS) program, version (26).
3. The project data, which are two-dimensional AutoCAD files, bills of quantities, and some information about the project, were collected through interviews with engineers in the resident engineer department of the Al-Ghalibyah Residential Complex.
4. Characterizing the building in this study employing photogrammetry and the extent to which the dimensions and quantities conform to the specifications, the Agisoft program, and Autodesk Recap.
5. Creating a 3D model using Autodesk Revit 2021 depending on 3D modeling by the Agisoft program, and Autodesk Recap.
6. Creating a 3D model using BIM technology and its applications for the purpose of improving and assuring the quality of construction projects by reducing their energy consumption.
7. The questionnaire method was used to evaluate the system for quality improvement in construction projects in Iraq by BIM.
8. Finally, displaying the conclusions, recommendations, and proposals for future research.

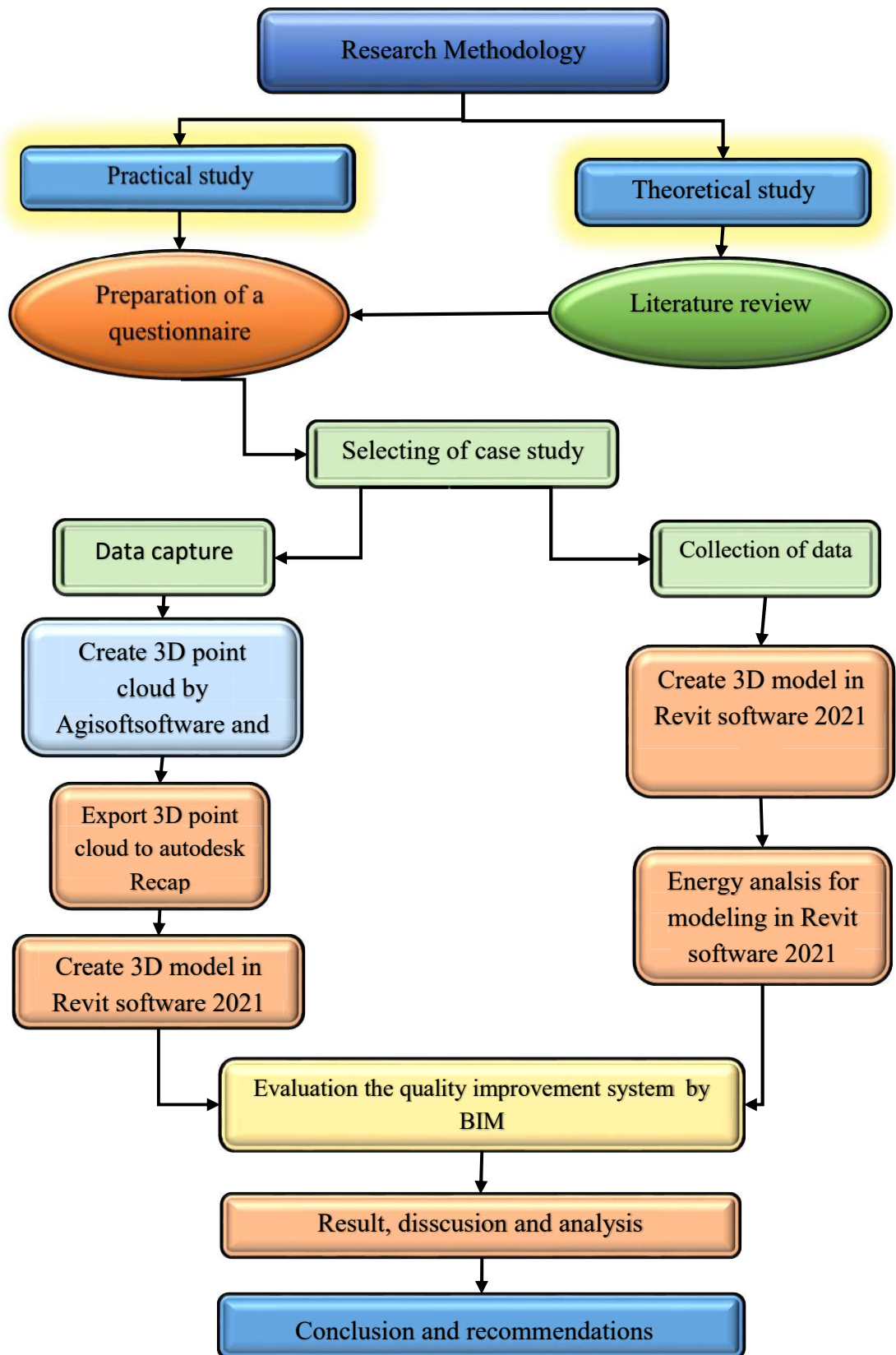


Figure (1-1): Research methodology (Researcher)

1.6 Thesis Structure

The research has been divided through this thesis into as follows:

Chapter One: Introduction

It presents general introduction to the study, the background of the research and justifications, research aim and objectives, research scope and limitation, description of the research methodology as well as explain previous studies.

Chapter Two: Literature Review

It contains a brief study about the quality of construction projects in Iraq, Execution Phase, Construction project constraints, Project quality control, concepts of quality and its definitions, quality in construction projects, assurance and control quality, total quality management, traditional tools of quality, computer-aided design (CAD), Building Information Model (BIM) of quality improvement, (BIM) the definitions, concepts, dimensions, The technologies and improving quality projects, BIM Applications, Photogrammetry and 3D Modeling, Energy analysis using BIM, and the advantages of using BIM in improving the quality of the execution.

Chapter Three: Execution Quality of Iraq Construction Projects

This chapter reviews the questionnaire method for evaluating the quality performance of construction projects execution in Iraq. It includes questions distributed to respondents working in the contracting sector to express their opinion on the quality of implementation currently used in construction projects as well as their knowledge of BIM technology to improve the quality. The results of this questionnaire are confirmed as the justifications for this thesis.

Chapter Four: Improving the Execution Quality by Building Information Modeling

This chapter will describe the following two important subjects:

The first subject was improving quality control using building information modeling for BIM-compliant construction projects using Agisoft software, Autodesk Recap, and Autodesk Revit software.

The second subject was improving quality assurance using building information modeling and energy analysis, which evaluates the energy usage in accordance with BIM using Autodesk Revit software, and Autodesk Green Building Studio (GBS) Cloud.

Chapter Five: Results and Discussions

This chapter will discuss the following three results themes:

The first topic is a comparison of the Q.T.O. between the as planned quantity (estimated), the actual quantity, and the as built quantity computed by Revit using BIM.

The second topic is the results of the energy analysis which measures the energy consumption for new materials and chooses the most applicable alternatives.

The third topic in this chapter is the evaluation of the improving the quality system for construction projects by BIM applications.

Chapter Six: Conclusions and Recommendations

It includes the research overall conclusions, recommendations, and proposals for future research study in this field.

1.7 Review of Previous Studies

Many researchers in different countries have investigated certain aspects improving the quality in the implementation stage of the BIM application. Table (1-1) provides a simple summary of these studies. The studies are divided according to their geographic location into three groups (local studies, Arab studies, and global studies).

Table (1-1): Review of previous studies

Local Studies (Iraqi studies)				
NO.	Researcher	Title	Year	Country
1	Ali Amer M. Hasan	Quality Evaluation of Construction Factories by Using 'Six Sigma' Approach	2011	Iraq
The work				
<p>This research studied the quality evaluation of construction factories of how concrete mixtures are improved to reach the quality of construction projects, using statistical methods and through the philosophy of Six Sigma. many conclusions have been reached and the results revealed that</p> <ol style="list-style-type: none"> 1. The lack of specialist departments for quality management, with the job of auditing processes from the beginning to the conclusion. 2. There is a dearth of use of statistical tools and mathematical methodologies to identify the fundamental causes of deviation or to analyze the manufacturing process. 				
2	Faiq Mohammed Sarhan AL-Zwainy, and Firas Khary Jaber	Quality control of concrete bored piles in overpasses projects in Iraq	2014	Iraq
The work				
<p>This research aims to study the reality of quality control in infrastructure projects (bridges) in Iraq, to clarify the factors that affect the quality control of concrete piles on-site for these projects using fishbone technology, to know the relative importance of these projects. Factors, to evaluate the field application by looking at the scientific basis for quality control in construction projects, to reach a set of conclusions and recommendations aimed at improving the quality control process in projects. Finally it was concluded that the overpass projects in Iraq suffer from a lack of efficient staff and specialized workers in the quality control field, with a relative importance of 90%, a lack of statistical methods for operations modeling, with a relative importance of 83 %, and a lack of information system for quality control.</p>				

3	Nidal Adnan Jasim	Diagnosing the Causes of Poor Quality Management in Iraqi Construction Projects Using Technique of Root Cause Analysis	2021	Iraq
The work				
<p>The root cause identification approach has been used. The purpose of this research is to identify the reasons for poor quality management in Iraqi construction projects across several categories, such as equipment, labor, systems, materials, design and execution, subcontractors, site personnel, and contract. The findings developed and diagnosed fifty-three reasons for poor quality management in Iraqi building projects in general; however, Pareto analysis revealed that only thirty-five of the causes were the most relevant. There were eight reasons in the systems group, seven in the design and execution group, five in the materials group, and three in the subcontractor's group. Two factors account for the majority of the reasons in the site staff group.</p>				
Arabic Studies				
NO.	Researcher	Title	Year	Country
1	Maya Rana, Omran Jamal, Hassan Bassam	Quality Information Modeling for Construction Using BIM Autodesk 360 Field	2014	Syria
The work				
<p>In this research, it is proposed to use BIM Autodesk 360 Field as a tool for modeling and managing high-quality information in construction. This will be achieved by appropriately tracking the condition of materials and equipment, documenting work, resolving difficulties, visualizing construction processes, and increasing communication and collaboration. The case study's use of the program's Quality Assurance and Quality Control (QA/QC) checklists resulted in 187 quality and safety issues. This shows unequivocally that the personal follow-up of the tasks performed and quality control equipment, visual interference, documentation, and reporting are becoming obsolete and inefficient.</p>				
2	Sadek, Khaled; El-Bastawissi, Ibtihal; Raslan, Rokia; and Sayary, Samer	Impact of BIM on Building Design Quality	2019	Lebanon

The work				
<p>This research proposes a set of hypotheses that links the BIM execution with the improvement of information sharing capability (ISC) and collaborative decision capability (CDC) in the construction sector of the building industry. Consequently, it relates the degree of BIM use to the design quality improvement using ISC and CDC as mediators. The study uses three sets of criteria for the improvement of the design quality as indicators to enhance the project quality benefit, form, aesthetic qualities, and building construction quality. The study suggests a new conceptual model establishing the probable relationships between the variables included in the study. As a result, it has various implications for practitioners and decision-makers on the relevance of BIM in improving project quality.</p>				
3	Mohammad Abazid, Hüseyin Gökçekuş, and Tahir Çelik	Study of the Quality Concepts Implementation in the Construction of Projects in Saudi Arabia by using Building Information Modelling (BIM)	2019	Saudi Arabia
The work				
<p>In this research study, the descriptive-analytical technique was employed to attain the study's goal by distributing 12 questionnaires in engineering offices and construction enterprises. The SPSS application was used to process the acquired data. According to the findings of the study, construction projects in Saudi Arabia continue to suffer from weaknesses in the application of Building Information Modeling (BIM), a lack of administrative, scientific, and technical competencies, and a poor application of quality concepts in the execution of construction projects.</p>				
Global Studies				
NO.	Researcher	Title	Year	Country
1	Ying-Mei Cheng	Building Information Modeling for Quality Management	2018	China
The work				
<p>This study focuses on the application framework of BIM on quality management. The core concepts of quality management include quality control, quality assurance and communication protocol. The communication protocols encompass: 1) Organizational structure and responsibilities of project stakeholders; 2) Communication channels; 3) Frequency of information exchange. Based on this framework, a QC (Quality Control) model system prototype is established. The QC model was utilized in the construction stage with Autodesk Revit API (Application Programming Interface) which greatly improves the collaborative work while effectively reducing the costs at the same time.</p>				

2	Ammad Hassan Khan, Ali Imran, and Muzamil Hussain	Evaluation of Quality during Construction Projects: A Case Study of Pakistan	2019	Pakistan
The work				
<p>Quality ideals must be attained and maintained to achieve organizational and consumer satisfaction. This study looks into several areas of operationalizing quality culture and variables influencing the quality of building construction in developing countries like Pakistan. A qualitative and quantitative survey was distributed among various stakeholders, including Clients, Consultants, and Contractors, to assess the level of the contractor's performance, project monitoring and controlling techniques, proper, client satisfaction, and workers' experience in the construction industry projects. According to this investigation, political and socio-economic issues have a crucial influence in sustaining the quality level in the local industry. As a result, adequate resources should be allocated, workers should be properly trained, quality control personnel should be hired, and a new technology should be used to ensure appropriate QMS (Quality Management System) implementation.</p>				
3	Choi, Jungsik Lee, Sejin Kim, Inhan	Development of Quality Control Requirements for Improving the Quality of Architectural Design Based on BIM	2020	Korea
The work				
<p>The goal of this research is to create and implement quality control standards for a better quality architectural design using BIM. To accomplish this, the study defined quality check objectives for the BIM-based design phase by analyzing the business and output data for each phase of the architectural design process and extracting the detailed quality check objectives from the case, the research created space inspection standards, and design inspection standards, Finally, the study created a rule-based quality control system.</p>				
Current Study				
<p>This research explores the advantages of using BIM and its usefulness in improving the quality of execution in construction projects by making a virtual prototype of a building in a residential complex during employing photogrammetry by Agisoft, Recap software, and Revit software. In addition, BIM technology was used to assess the energy consumption of the study case and select the best choices for the application, based on a tool green building studio (GBS), where the study found a proposal for a special system to control, assure and continually improve the quality in the implementation phase using several BIM applications.</p>				

1.8 Summary

This chapter presents a brief introduction to improve quality by BIM, a description of the justification for research, a description of the aim and objectives of the research, research scope, and limitations, the methodology of research, in brief, the structure of the thesis, and finally the review of previous studies.